Electrical Boards (EELE 5421)
Course outline

By Prof. Dr. Muhammed Abdelati

Week	Chapter	Subject
1-2	1. Electrical subscription	1.1 Introduction to Electrical subscription ratings and boards (single line, Layout, Bill of Quantity (BOQ)) 1.2 House-use subscriptions ○ One user single phase ○ One user 3 phase ○ Small Building comprises 6 single phase & one 3 phase subscriptions ○ Tower building comprises 44 single phase & one 3 phase subscriptions 1.3 Industrial subscriptions ○ 100-400 A subscriptions ○ 630-1600 A subscriptions ○ 2000-2600 A subscriptions 1.4 Change over power circuit 1.5 Active and reactive power meters illegal tricks 1.6 Indicators and meters 1.7 Power factor correction 1.8 Transformers ratings and wiring connections
3	2. Introduction to AutoCad	2.1 AutoCAD tutorial 2.2 Electrical symbols (installations diagrams, electrical circuits) 2.3 International Protection (IP) rating
4-5	3. Soft starting of three phase motors using RVS-DN	3.1 Standard wiring 3.2 Direction control 3.3 Inside Delta connection 3.4 Power factor correcting capacitor connection 3.5 Analysis of the power circuit of a water pump board 3.6 Programming
6-7	4. Pump control	4. 1 Temperature sensors 1. Thermocouples • J • K • S 2. Resistive Temperature Devices (RTD) • PRTs ➢ PT100 ➢ PT1000 • Ni 3. Thermistors • PTC • NTC 4. Semiconductor temperature sensors 4.2 Overload Monitoring relay (EMT6) 4.3 Pump control and status modules (Flyget CAS) 4.4 Control circuit of a water pump board
8		***Review & 1st Midterm***
9	5. Electrical Cables	5.1 Cable standards • DIN VDE 0281/0282 • DIN VDE 0271/0272/0273/0276 5.2 Cable selection criteria
10-11	6. Speed control of 3 phase motors using VFD	6.1 circuit diagram 6.2 programming through interface buttons 6.3 programming through PC. 6.4 RS485 protocol interface
12	7. Generators boards	Change over control circuit Generator Synchronizing boards
13-14	8. Selected Projects	8.1 Water pump station 8.2 Soft drink Factory 8.3 Wastewater pump station
15		***Review & 2^{ed} Midterm***

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electric boards

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CHAPTER 1

Introduction to Electrical subscription ratings

Introduction to change over power circuit.

Active and reactive power meters illegal tricks

Indicators and meters

Power factor correction

Transformers ratings and wiring connections

Table of Contents

1.1 Introduction to Electrical subscription ratings.

The electricity distribution companies distribute electricity to consumers in accordance with a particular system so that they can be reconciled between the power distribution network and consumer demand in general subscriptions divided into two kinds the household subscriptions -low power- and the industrial subscriptions- high-power- , the price required from the consumer is accordance with these Regulations.

1.1.1. Subscriptions types depending on electrical use: is divided as follows:

- commercial
- industrial
- agriculture
- services

1.1.2. Subscriptions are either 3 phase or be one phase: which according to the following:

a) Subscriptions homes with low power :
   - 1-phase 40A
   - 3-phase 30A
   - 3-phase 63A

b)Subscriptions industrial :
   - 3-phase 30A
   - 3-phase 63A
   - 3-phase 100A
   - 3-phase 160A
   - 3-phase 200A
   - 3-phase 250A
   - 3-phase 300A
   - 3-phase 400A
   - 3-phase 600A
   - 3-phase 1000A
   - 3-phase 1600A
   - 3-phase 2000A
   - 3-phase 2500A

1.1.3. some components used in electrical boards.

The Table 1.1 shown the component picture , description & it is symbol .

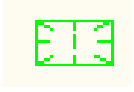
Symbol	Description	Picture
	1-PHASE CIRCUIT Breaker.	
	3-PHASE CIRCUIT BREAKER.	
	220V / 24 V SIGNAL LAMP.	
	XX/5A CURRENT TRANSFORMER.	
	5A ANALOGUE AMMETER.	
	400V VOLTMETER..	
	SEVEN STAGES INSTRUMENT SELECTOR SWITCH.	

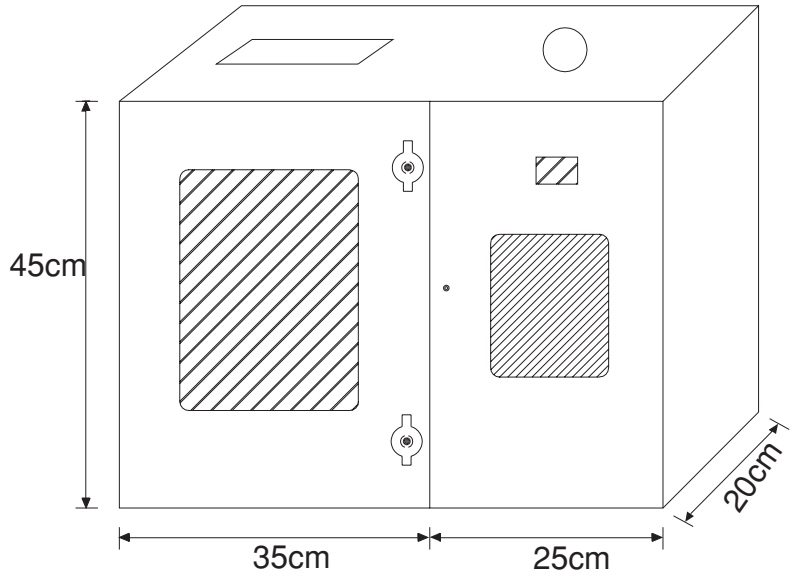
Table 1.1

1.2 house-use subscriptions.

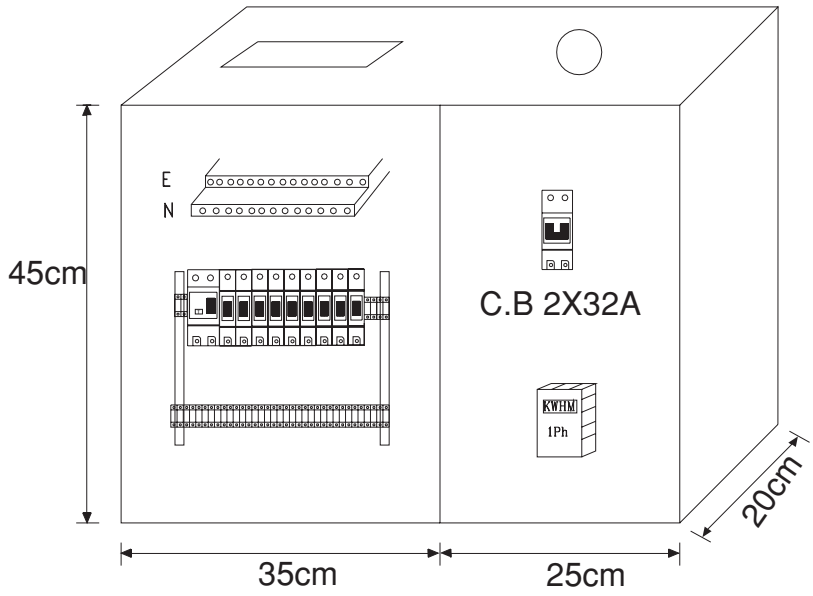
1.2.1. one user single phase.

a) Lay out of electric board.

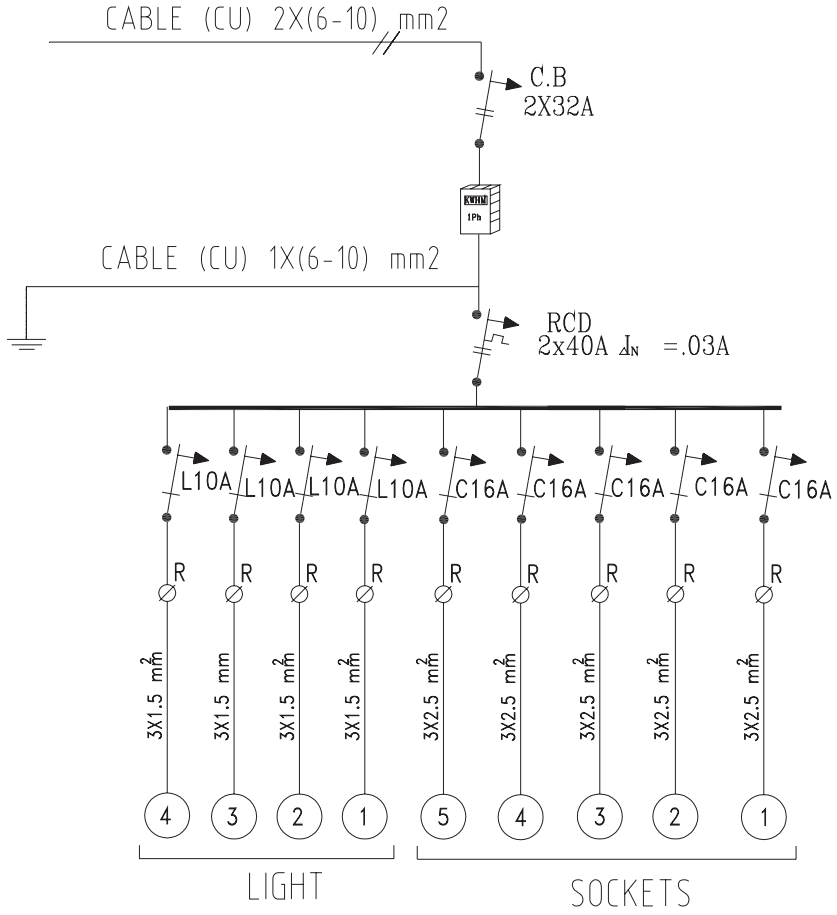
- Size 45X60X20 CM



b) Inside view .



c) Single line diagram .



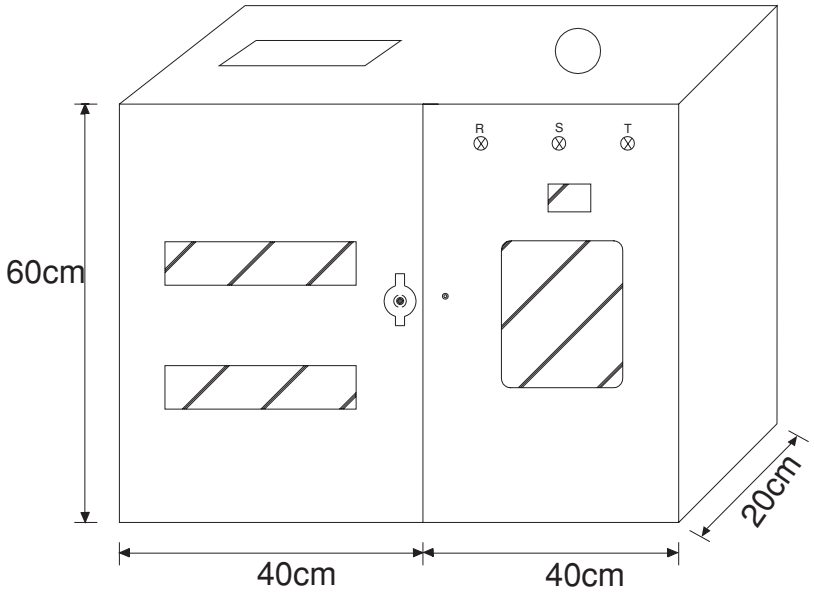
d) Bill of Quantity.

No.	Component	unit	Quantity
1.	C.B 2x32 A	piece	1
2.	R.C.D 2X40A	piece	1
3.	C.B 16 A	piece	8
4.	KWH 1-phase	piece	1
5.	CABLE (CU) 2 x (6-10) mm2	meter	30
6.	CABLE (CU) 1 x 6 mm2	meter	20

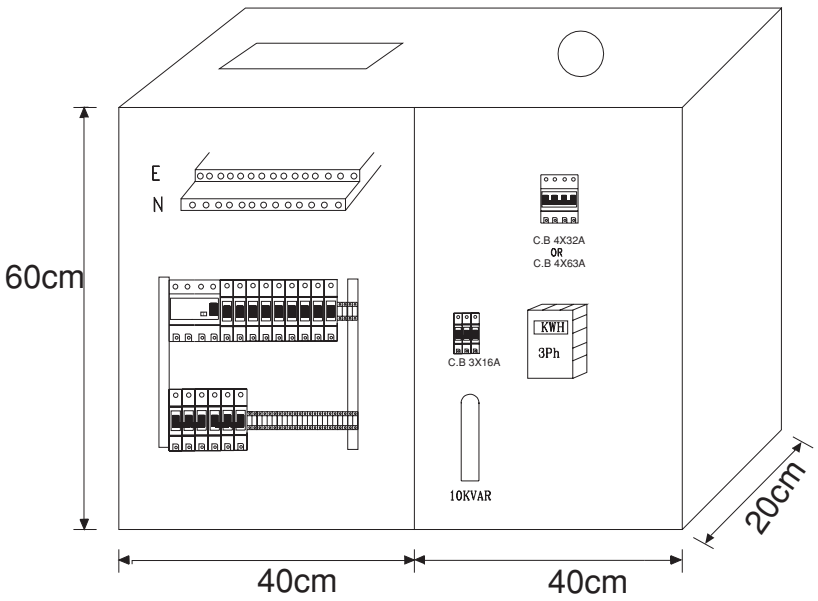
1.2.1. one user 3-phase.

a) Lay out of electric board.

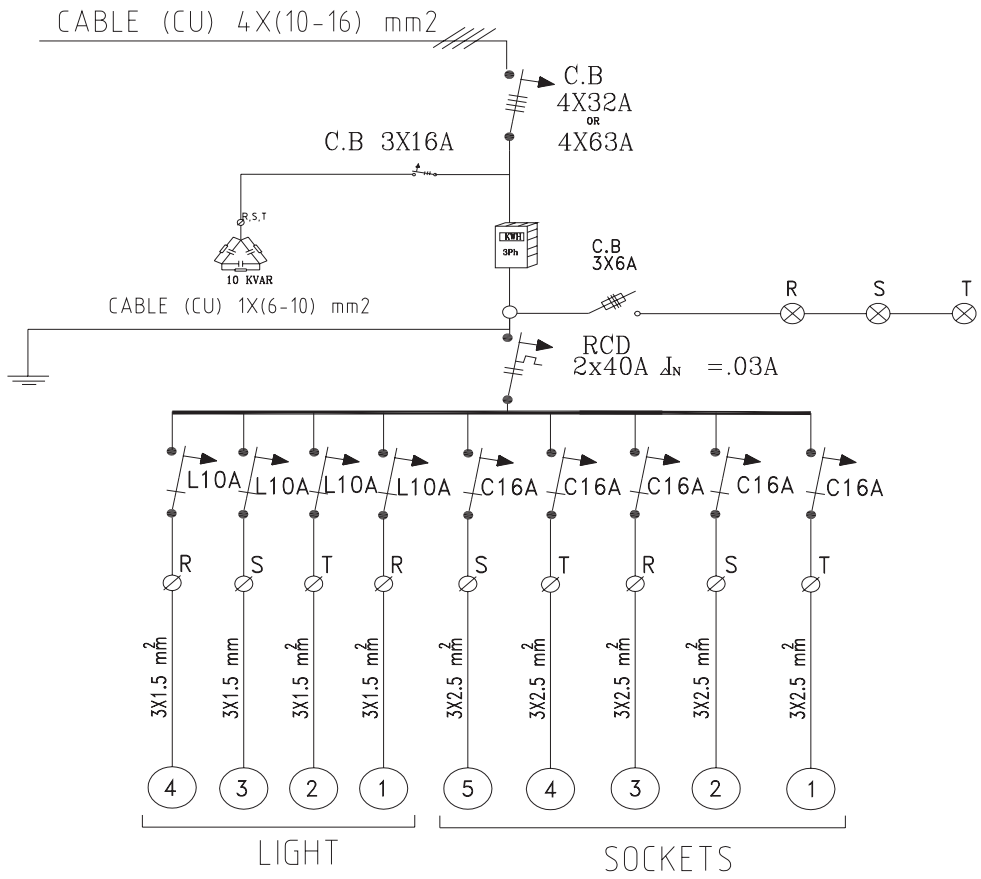
- Size 60X80X20 CM



b) Inside view .



c) Single line diagram .

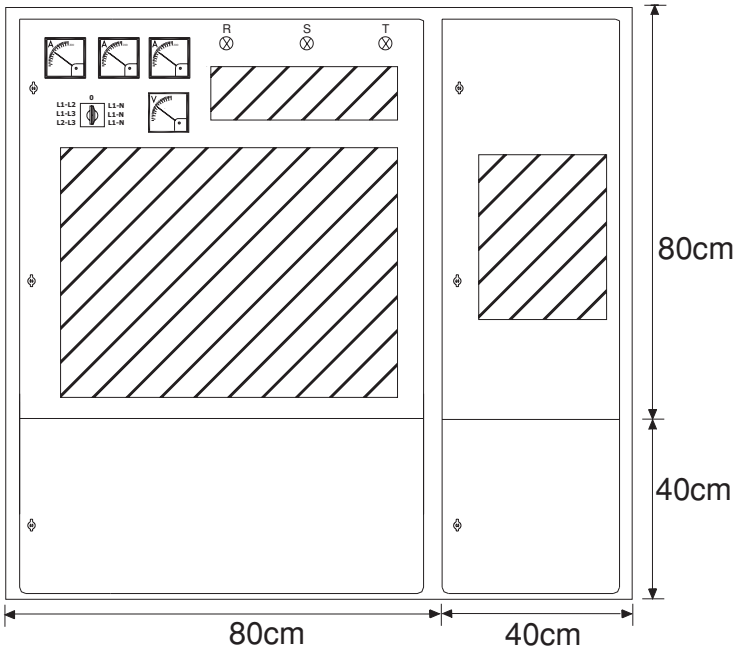


d) Bill of Quantity.

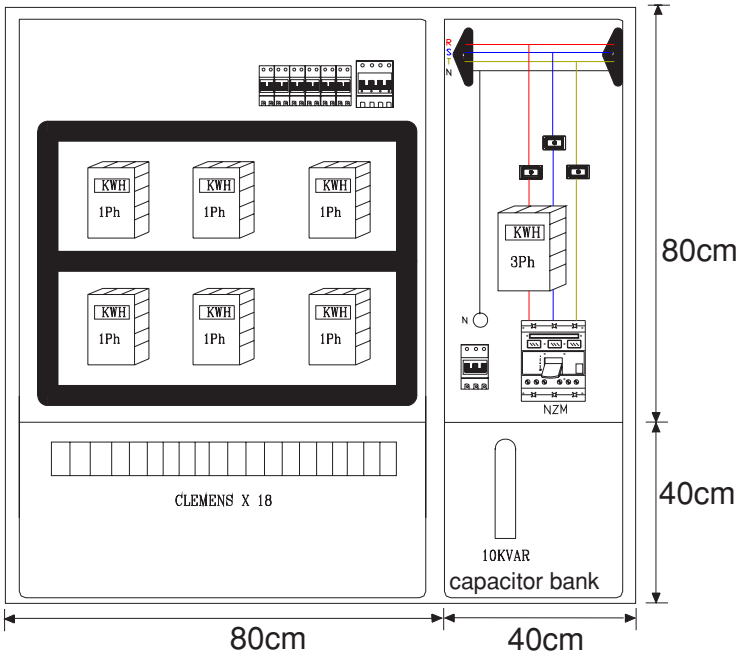
No.	Component	unit	Quantity
1.	C.B 4x32A OR 64 A	piece	1
2.	R.C.D 4X40A	piece	1
3.	C.B 16 A	piece	10
4.	C.B 6 A	piece	1
5.	SIGNAL LAMP	piece	3
6.	CAPACITOR BANK 10KVAR	piece	1
7.	KWH 1-phase	piece	1
8.	CABLE (CU) 4x (6-10) mm2	meter	30
9.	CABLE (CU) 1 x 6 mm2	meter	20

1.2.3. Small building comprises 6 single phase & one 3-phase subscriptions

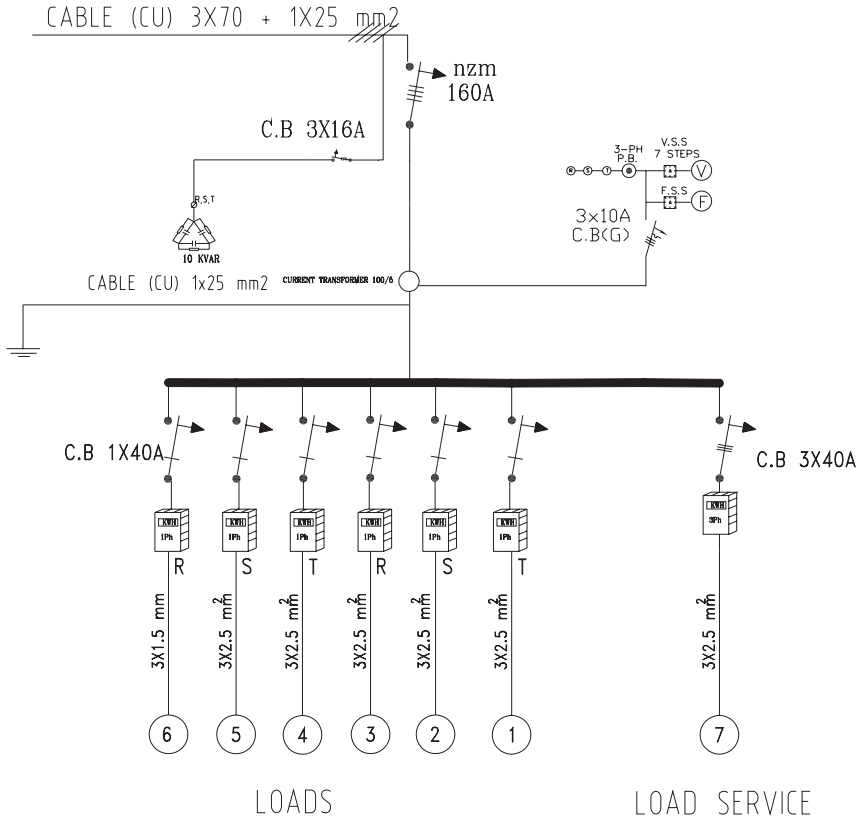
a) Lay out of electric board.



b) Inside view .



c) Single line diagram .



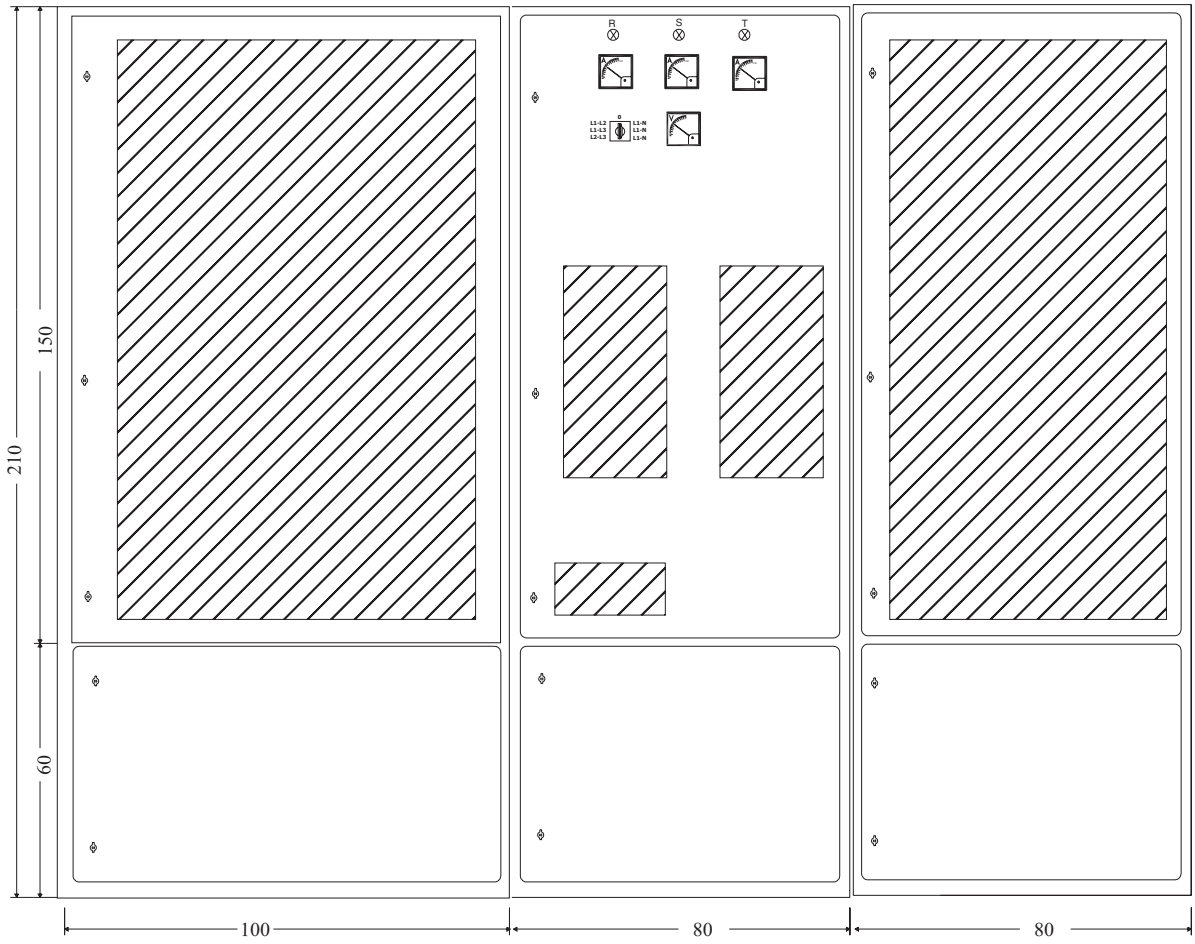
d) Bill of Quantity.

No.	Component	unit	Quantity
1.	NZM 160A	piece	1
2.	R.C.D 4X40A	piece	6
3.	SELECTOR SWITCH	piece	1
4.	FREQUANCY METER	piece	1
5.	VOLT METER	piece	3
6.	C.B 16 A	piece	1
7.	C.B 10 A	piece	1
8.	SIGNAL LAMP	piece	3
9.	CAPACITOR BANK 10KVAR	piece	1
10.	KWH 1-phase	piece	6
11.	KWH 3-phase	piece	1
12.	CABLE (CU) 4x 70 mm2	meter	200
13.	CABLE (CU) 1 x25 mm2	meter	150

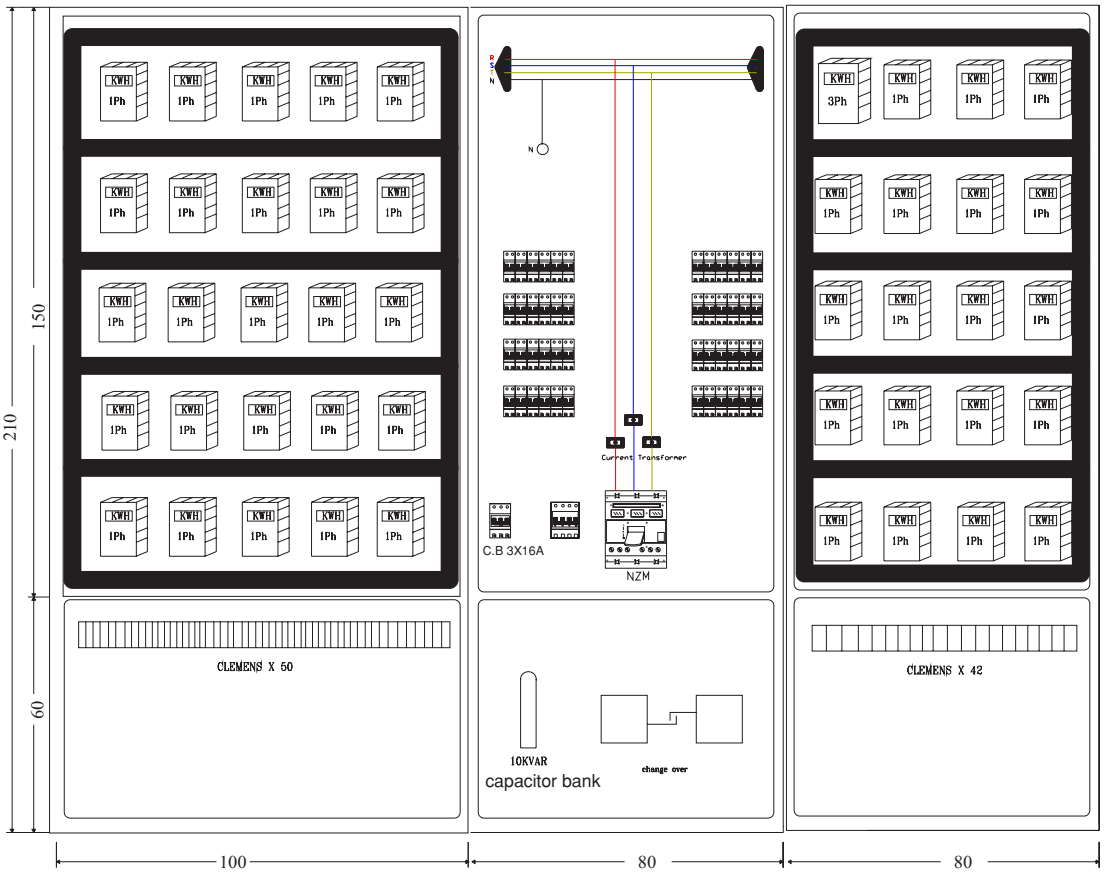
1.2.4. Tower building comprises 44 single phase & one 3-phase subscriptions.

a)Lay out of electric board.

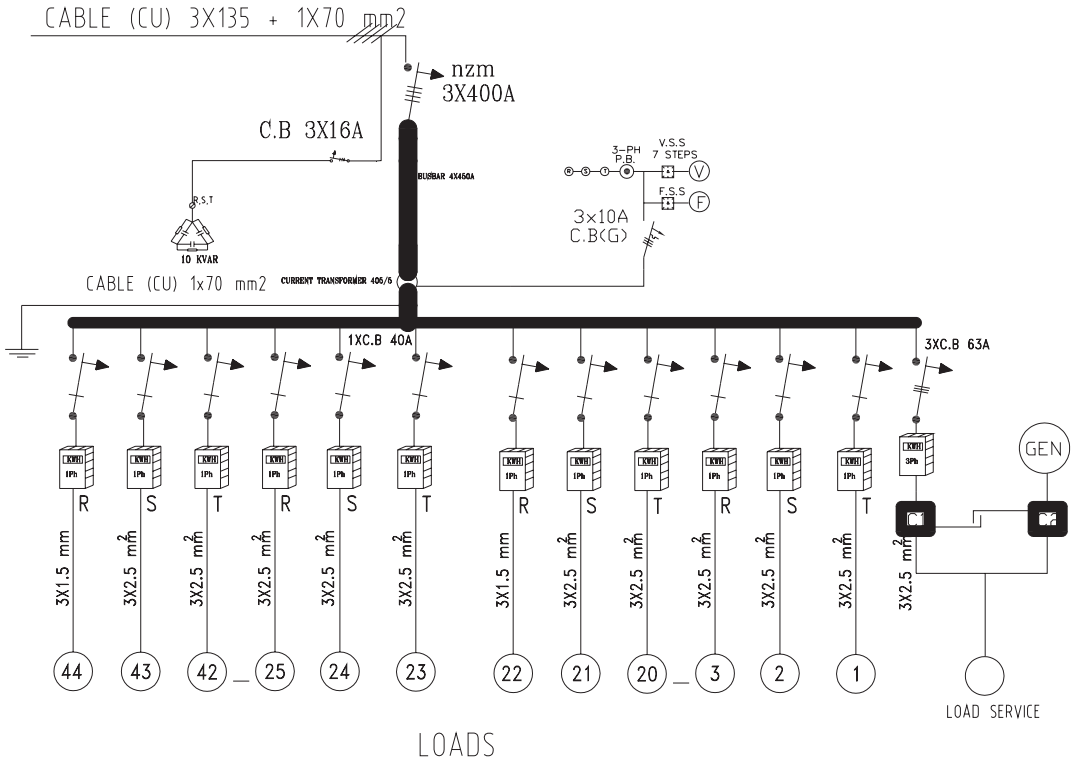
- Size 210X260X20 CM



b)Inside view .



c)Single line diagram .



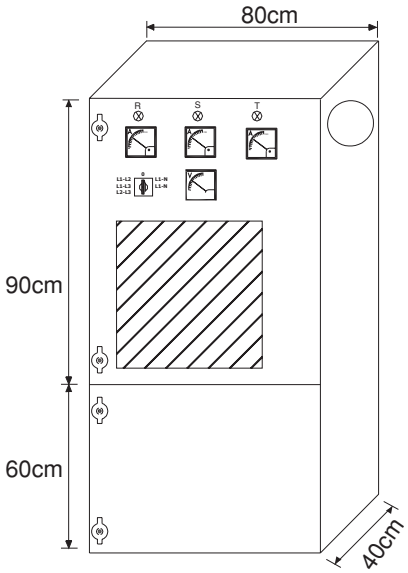
d)Bill of Quantity.

No.	Component	unit	Quantity
1.	NZM 400A	piece	1
2.	R.C.D 4X40A	piece	44
3.	SELECTOR SWITCH	piece	1
4.	FREQUANCY METER	piece	1
5.	VOLT METER	piece	3
6.	C.B 16 A	piece	1
7.	C.B 10 A	piece	1
8.	SIGNAL LAMP	piece	3
9.	CAPACITOR BANK 10KVAR	piece	1
10.	KWH 1-phase	piece	44
11.	KWH 3-phase	piece	1
12.	CABLE (CU) 4x 135 mm2	meter	200
13.	CABLE (CU) 1 x 70 mm2	meter	150

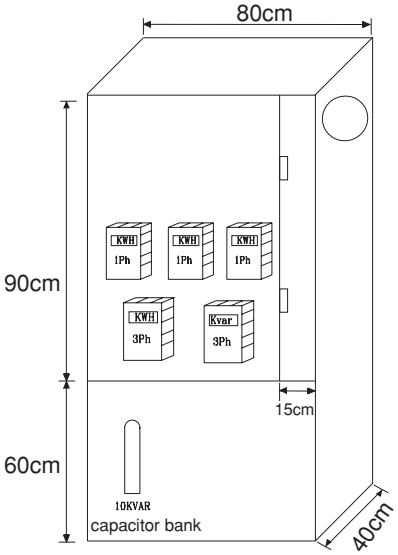
1.3 industrial subscriptions.

1.3.1. 100-400 A subscriptions

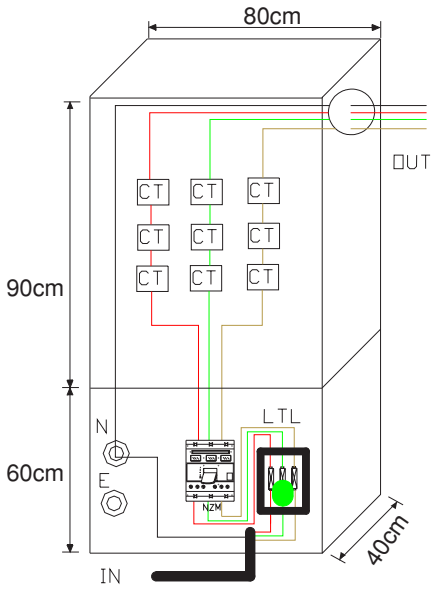
a) Lay out of electric board.



b) Inside view .

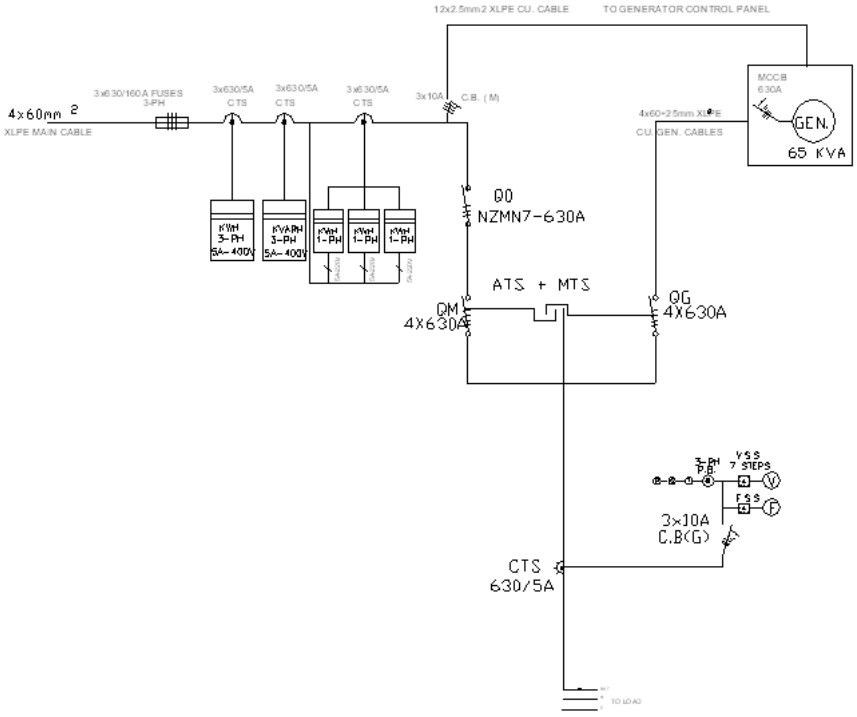


Front layer



back layer

c) Single line diagram .

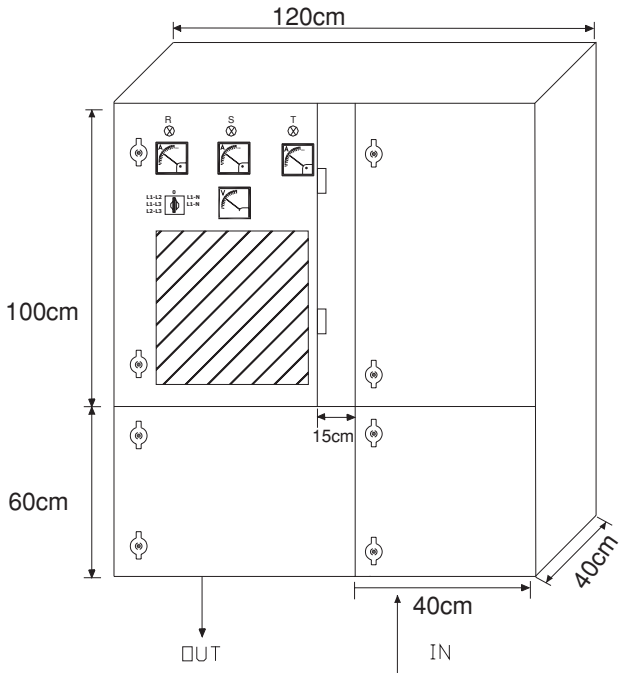


d) Bill of Quantity.

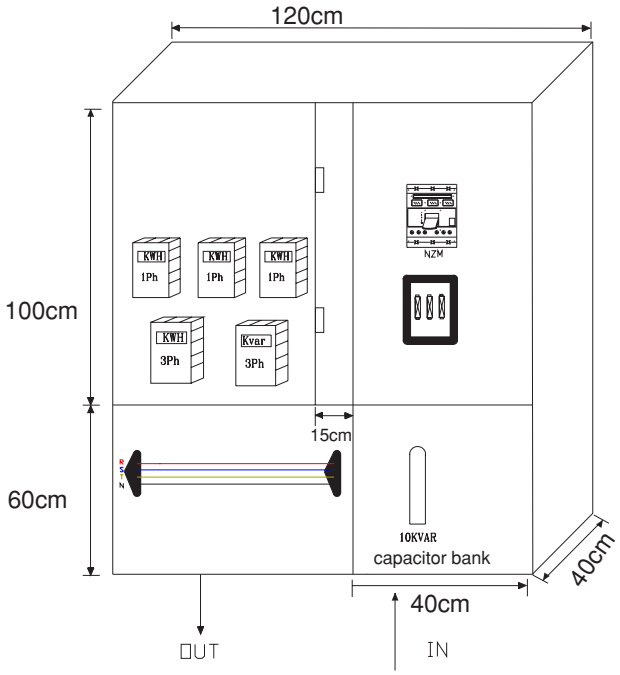
No.	Component	unit	Quantity
1.	NZM 100 - 400A	piece	1
2.	LTL 100 - 400A	piece	1
3.	SELECTOR SWITCH	piece	1
4.	FREQUANCY METER	piece	1
5.	VOLT METER	piece	3
6.	C.B 16 A	piece	1
7.	C.B 10 A	piece	1
8.	SIGNAL LAMP	piece	3
9.	CAPACITOR BANK 10KVAR	piece	1
10.	KWH 1-phase	piece	3
11.	KWH 3-phase	piece	1
12.	Kvar 3-phase	piece	1
13.	CABLE (CU) 4x 35 mm2	meter	200
14.	CABLE (CU) 1 x 70 mm2	meter	150

1.3.2. 630-1600 A subscriptions.

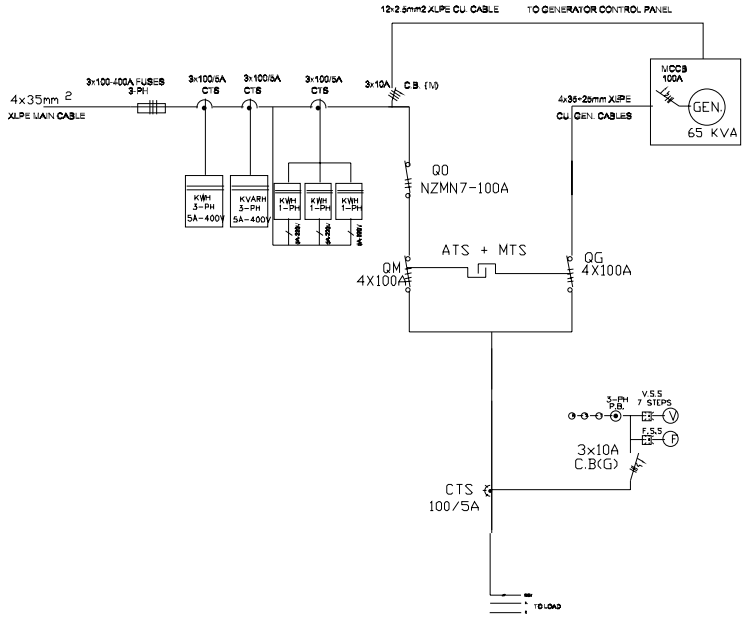
a) Lay out of electric board.



b) Inside view .



c) Single line diagram .

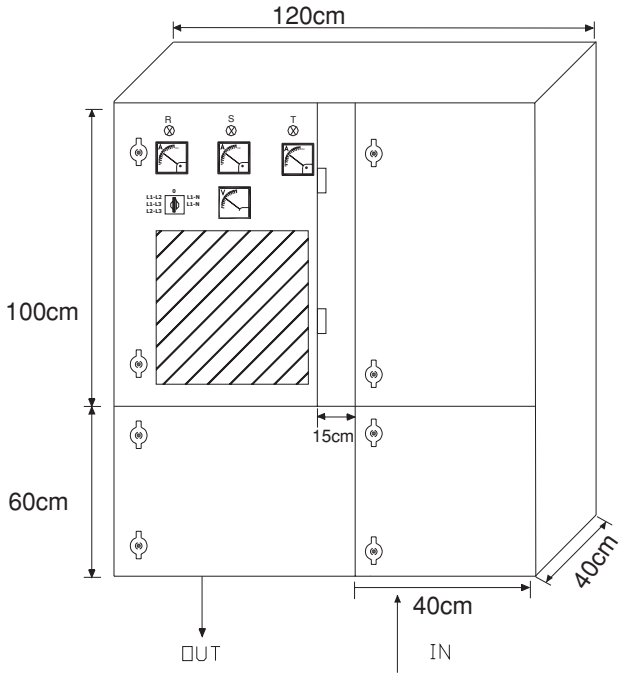


d) Bill of Quantity.

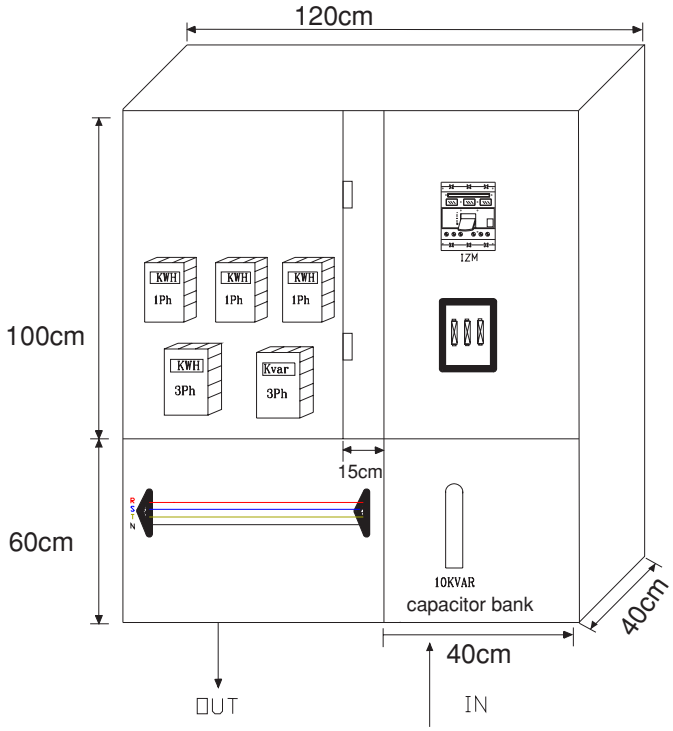
No.	Component	unit	Quantity
1.	NZM 630 - 1600A	piece	1
2.	LTL 100 - 630A	piece	1
3.	SELECTOR SWITCH	piece	1
4.	FREQUANCY METER	piece	1
5.	VOLT METER	piece	3
6.	C.B 16 A	piece	1
7.	C.B 10 A	piece	1
8.	SIGNAL LAMP	piece	3
9.	CAPACITOR BANK 10KVAR	piece	1
10.	KWH 1-phase	piece	3
11.	KWH 3-phase	piece	1
12.	Kvar 3-phase	piece	1
13.	CABLE (CU) 4x 60 mm2	meter	200
14.	CABLE (CU) 1 x 90 mm2	meter	150

1.3.3. 2000-2600 A subscriptions.

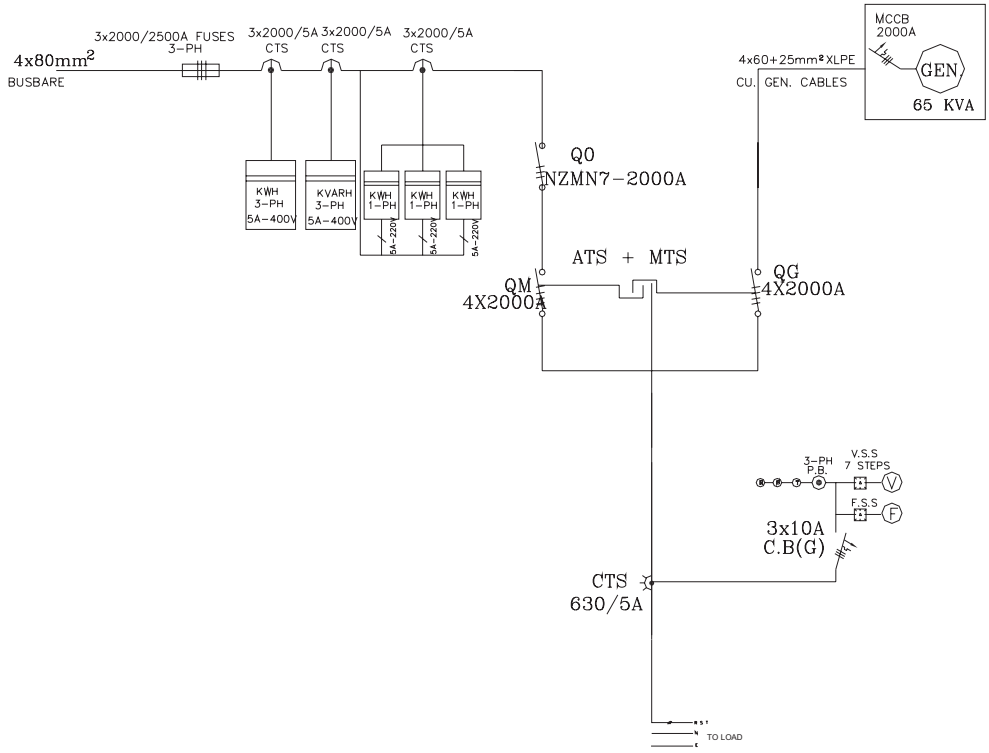
e) Lay out of electric board.



b)Inside view .



c)Single line diagram .



d)Bill of Quantity.

No.	Component	unit	Quantity
1.	IZM 2000 - 2600A	piece	1
2.	LTL 100 - 2000A	piece	1
3.	SELECTOR SWITCH	piece	1
4.	FREQUANCY METER	piece	1
5.	VOLT METER	piece	3
6.	C.B 16 A	piece	1
7.	C.B 10 A	piece	1
8.	SIGNAL LAMP	piece	3
9.	CAPACITOR BANK 10KVAR	piece	1
10.	KWH 1-phase	piece	3
11.	KWH 3-phase	piece	1
12.	Kvar 3-phase	piece	1
13.	CABLE (CU) 4x 80 mm2	meter	200
14.	CABLE (CU) 1 x 90 mm2	meter	150

1.4 Introduction to change over power circuit.

One of the most commonly used circuit in power networks is change over switch circuit which transfer the power flow from the main power source to the stand by source which may be generator set look at figure 1.4.

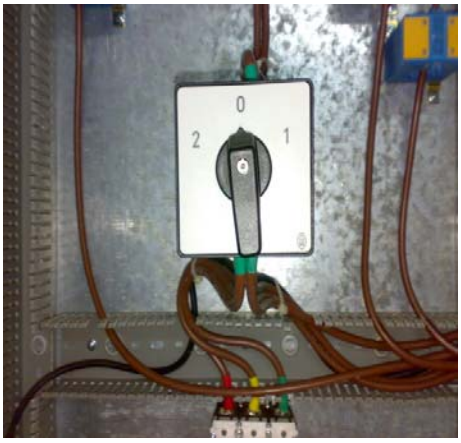
1.4.1 Change Over classified:

- Transfer Switch between Generator and Utility.
- Transfer Switch between Utility and another utility.
- Transfer Switch between Generator and another Generator.

1.4.2 Change Over types:

- **Manual Transfer Switches (MTS):** are generally the least expensive and least complicated of the two types of transfer switches. MTS's require someone to be on-site to start and shut down the generator look at figure 1.4.2 (a).
- **Automatic Transfer Switches (ATS):** monitor the power supplies and automatically switch from the normal (utility) supply over to the generator supplied power source in the event of a power outage. ATS equipment can have many different control and alarm features look at figure 1.4.2 (b).

a

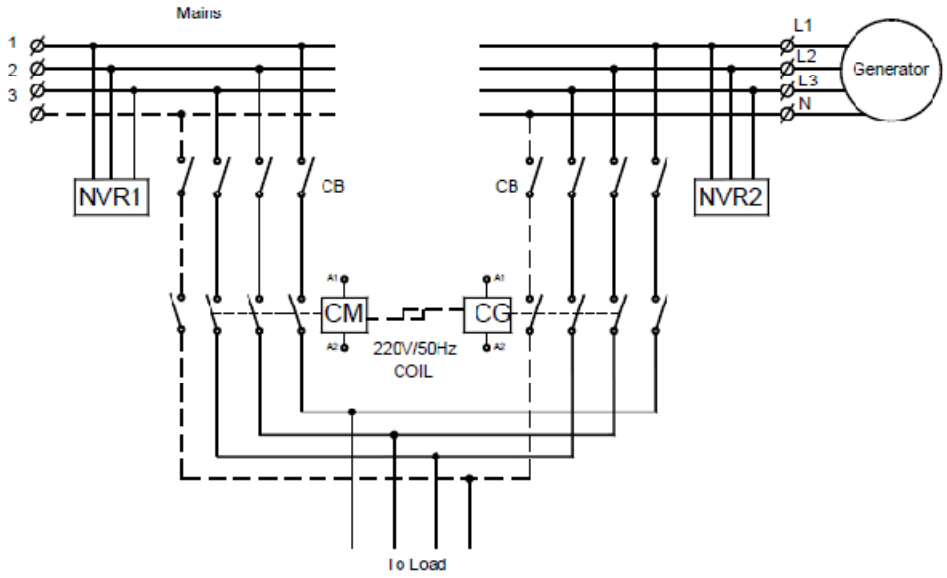


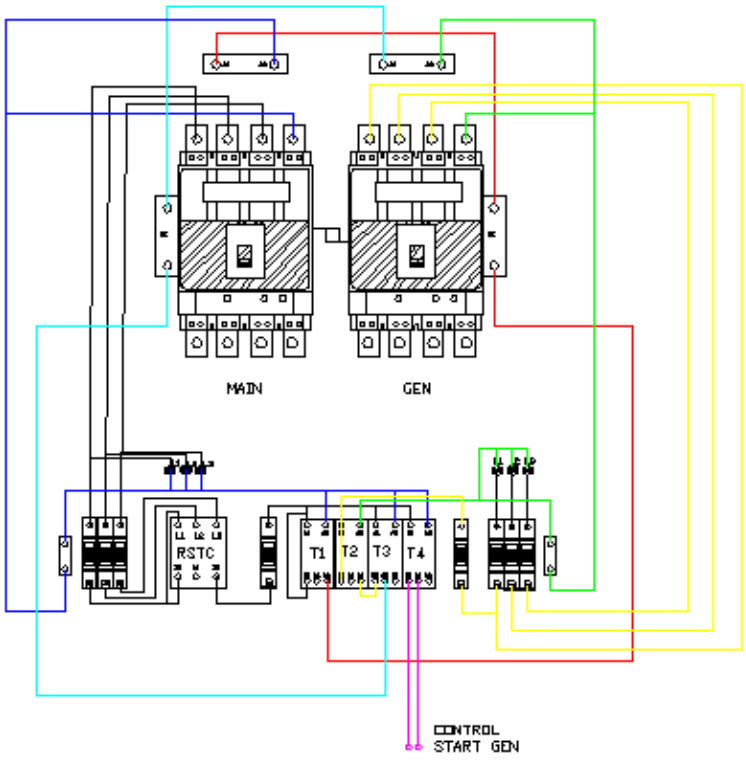
b

figure 1.4.2

1.4.3 Change Over power circuit:

That is the schematic of power circuit of ATS change over .





1.5 Active and reactive power meters illegal tricks.

Modern electricity meters operate by continuously measuring the instantaneous voltage (volts) and current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (joules, kilowatt-hours etc). The meters fall into two basic categories, electromechanical and electronic,The most common type of electricity meter is the Thomson or electromechanical induction watt-hour meter, invented by Elihu Thomson in 1888.

1.5.1 Electromechanical technology

The electromechanical induction meter operates by counting the revolutions of an aluminium disc which is made to rotate at a speed proportional to the power. The number of revolutions is thus proportional to the energy usage. It consumes a small amount of power, typically around 2 watts.

The metallic disc is acted upon by two coils. One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees using a lag coil. This produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and voltage. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc. The equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power being used. The disc drives a register mechanism which integrates the speed of the disc over time by counting revolutions, much like the odometer in a car, in order to render a measurement of the total energy used over a period of time.

In practical electricity meter divided for two kind watch meter and load meter,connection diagram are different and explaine in figure1 & figure2 .

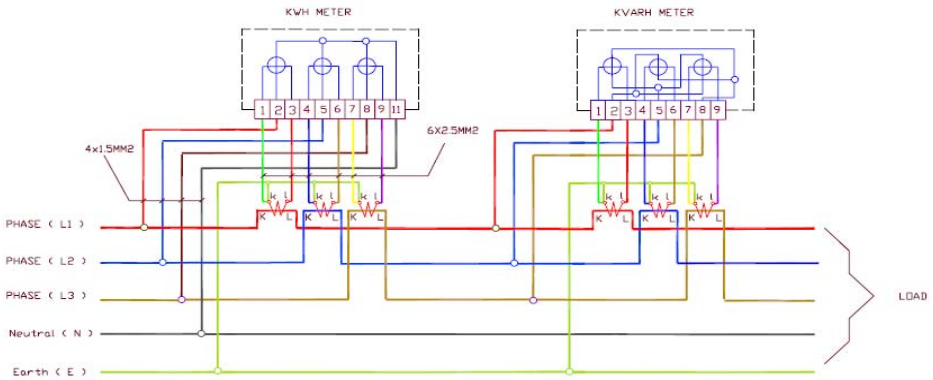


Figure 1 :watch meter connection

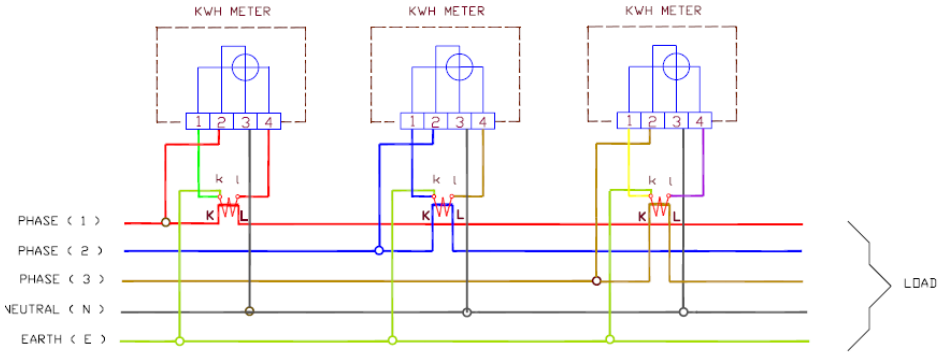


Figure 2 :watch meter connection

1.5.2 Active and Reactive Power Meters Illegal Tricks:

1- In the 3-phase KWh meter there is an illegal trick that is, if we change one phase input only by an output phase, then, the rotating rod will rotate in a very slow speed look at Figure1.5.2 a.
2- If we decline the KWh meter by a specified angle, then ,the rotating rod will not rotate.
3- For the KWh meters in which the rotating rod is made of metal, then , the rotating rod will stop if we put a magnet beside it.
4- In the 1-phase KWh meter there is an illegal trick that is, if we interchange the input phase & Neutral by output phase & Neutral, then, the rotating rod will rotate in a reverse manner.

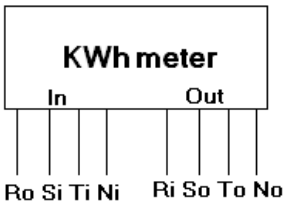


Figure1.5.2 a

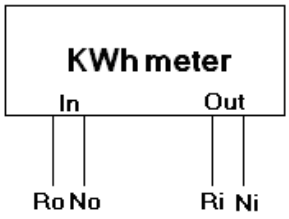


Figure1.5.2 b

5- We can make a change over switch between output and the input to the KWh meter look at Figure1.5.2 c.

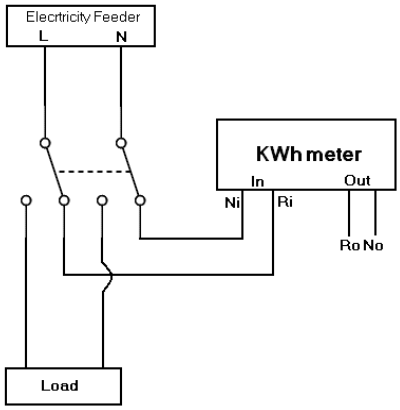


Figure1.5.2 c

6- We can connect a junction between the neutral input and neutral output in the KWh meter look at Figure1.5.2 c.

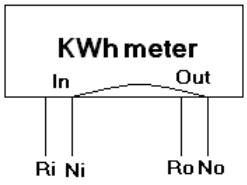


Figure1.5.2 d

7- Enter L and N cable but at the output only take L cable take N from Ground as shown Figure1.5.2 e.

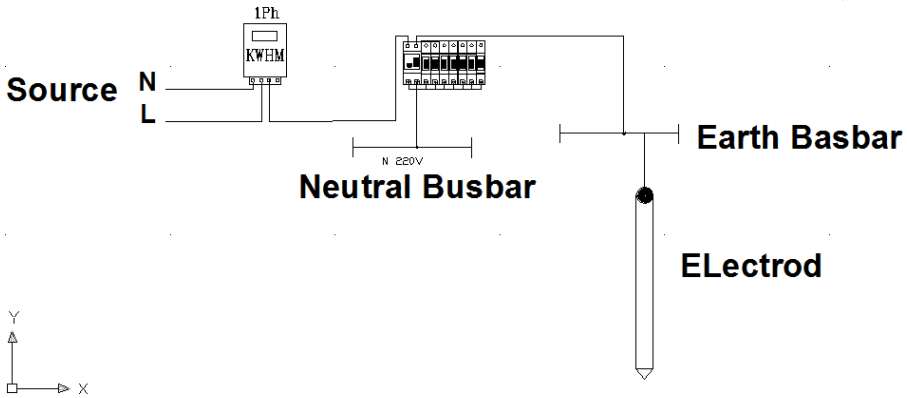


Figure1.5.2 e.

1.6 Indicators and meters.

A panel meter is an instrument that displays an input signal for AC & DC output and input distribution circuit, power plant console cabinet, power operating board and different apparatus. It is used to measure DC current, voltage & AC current, voltage, frequency and phase power.

1.6.1 panel meters types:

- Digital panel meters as shown in figure 1.6.1 a.
- Analog panel meters as shown in figure 1.6.1 b.

Figure 1.6.1 b.

Figure 1.6.1 a.

1.6.2 Example of digital panel meter:

KMM 01U digital multimeter

KMM 01U is very advanced multimeter which gives user precise readings in 4 digits and separate CT ratio adjustments for flexible systems. It is not only measures the current pulled from the L1, L2, L3 but also voltage and frequency of those lines in True RMS. All measured values are displayed in 5 rows, 3 rows for 3 ampere meter, one for the voltage that is cycling every 3 seconds (VL1, VL2, VL3, VL1-L2, VL1-L3, VL2-L3) and one for the frequency of the line voltmeter shows (between phases shows the first phase's frequency).

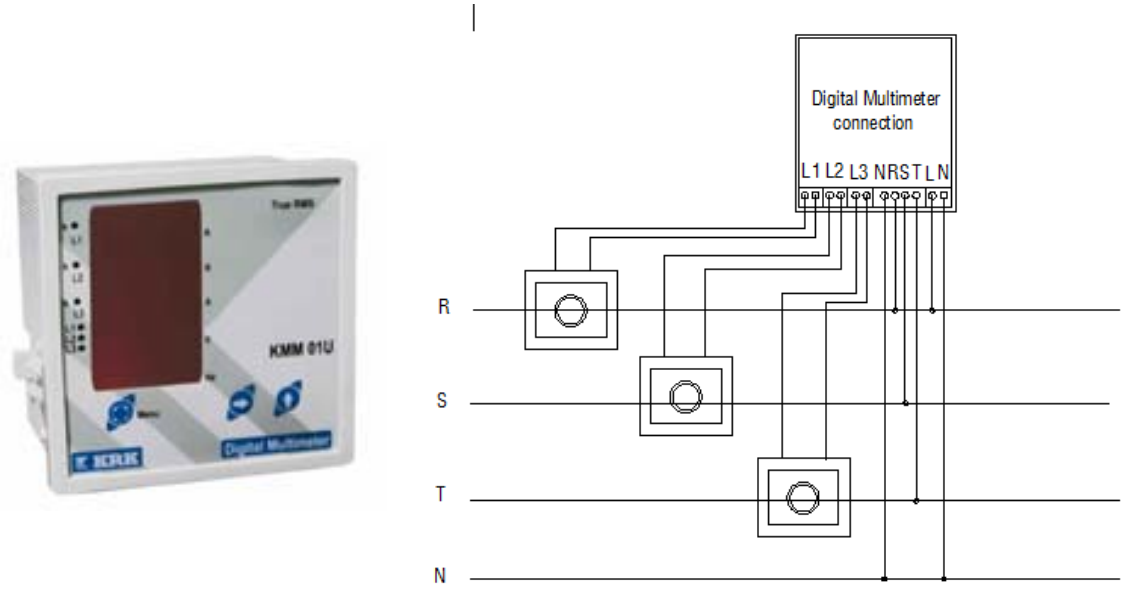
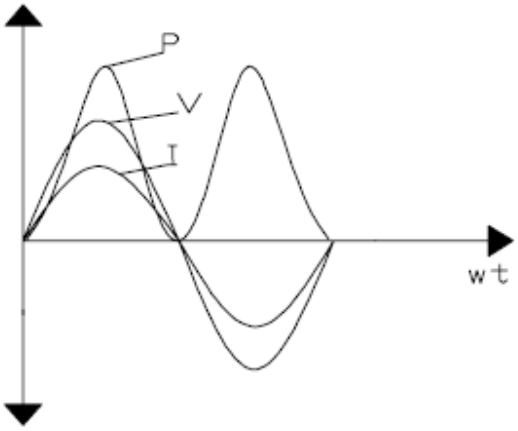


Figure 1.4: digital multimeter connection diagram

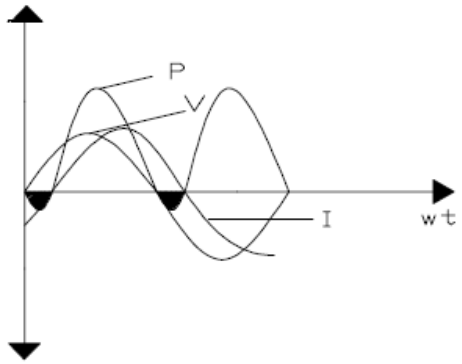
1.7 Power factor correction.

1.7.1 Active Power:



Pure resistive loads convert the Electrical Power to another form viz., Heat, Light or Mechanical Power. For, these type of loads which have no Inductive or capacitive components, the voltage and current waveform intersect the “Zero” co-ordinate at the same point.

For such Resistive loads, the voltage and current are set to be “In-Phase”. The active Power “P” is calculated as the Product of momentary voltage and current with a “P” frequency double to that of voltage supply and it is entirely on the positive area. With the resistive or ohmic loads, “P” power is calculated by multiplying the momentary values of Voltage and Current P = v(t) x i(t) as shown in figure 1.7.1 a.



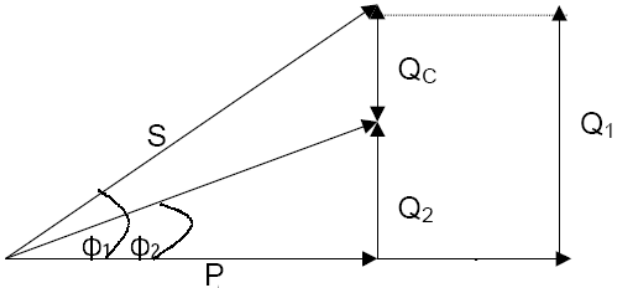
In practice, it is unusual to find purely resistive loads, since most of the electrical equipments has Inductive components and they operate in the presence of magnetic field like Motor, Transformer etc. The current which is used to create and reverse the magnetic field is not dissipated, but flows to and fro as Reactive Current between the Source and the Load. As illustrated in the figure1.7.1 b, the voltage and current waveform no longer intersect the “Zero” Co-ordinate at the same point, but with the displacement normally referred as displacement angle. With magnetic / inductive loads, the current lags the voltage whereas with the capacitive loads the current leads the voltage and the power will be P = V * I * Cos ø.

1.7.2 Power Factor :

The cosine of angle of Phase displacement between voltage and current in an a.c circuit is known as Power Factor. The Reactive component is a measure of the Power Factor. If the Reactive component is small, the Phase angle - is small and hence the Power Factor Cos ǿ will be high.

Therefore, a circuit having small reactive current will have high Power Factor

Cos φ = P / S = Active Power/Apparent Power



The Power Factor at full load is normally given on the nameplates of the electrical machines. As the Power distribution system must be dimensioned to carry the apparent power, efforts are made to keep this as low as possible. If a device taking leading reactive power (e.g. capacitor) is connected in parallel with the load, lagging reactive power of the load will be partly neutralized thus improving the Power Factor of the load The reactive power Qc corrected by the capacitor is given by the difference between the Inductive Reactive Power Q1 before correction and the reactive power Q2 after correction i.e. Qc = Q1 – Q2.

1.7.3 ADVANTAGES COMPARED TO CAPACITOR BANK

1. Low cost.
2. Stabilizing power.
3. Reduce cost of maintenance and servicing.
4. Prolong the life span of electrical appliances and fixed asset.
5. Prolong the Main Capacitor Bank.
6. Long Life Span.
7. Low risk and easy to maintain.
8. STAR Connection.

1.7.4 improving power factor :

We can improve the power factor from the following formula:

$$Q_C = P.\ (\tan \varphi_{\text{actual}} - \tan \varphi_{\text{desired}})$$

for example :

Measured Apparent Current I_S : 248 Amps

Power Factor cos φ1 : 0.86

Desired Cos φ2 : 0.92

Voltage V : 397 V

$P = \sqrt{3} * 397 * 248 * 0.86 * 10^{-3}$

$P = 146.6$ KW

$Q_C = P.\ (\tan \varphi_{\text{actual}} - \tan \varphi_{\text{desired}})$

$= 146.6(0.59 - 0.42)$

$= 24.9$ KVAR

1.7.5 connection of capacitor bank:

1. **Direct System**: Suit for premises use by small power consumer (SPC) that facing the low power factor problem. It can be used from a small percentage of power factors in a small amps usage until the highest percentage of power factor in a high amps usage as shown in figure 1.7.5 a.

figure 1.7.5 a

2. Jointly Control System: Suit for Large Power Consumer (LPC) such as factory, shopping complex, large institution, hospital etc that using the capacitor banks as shown in figure 1.7.5 b.

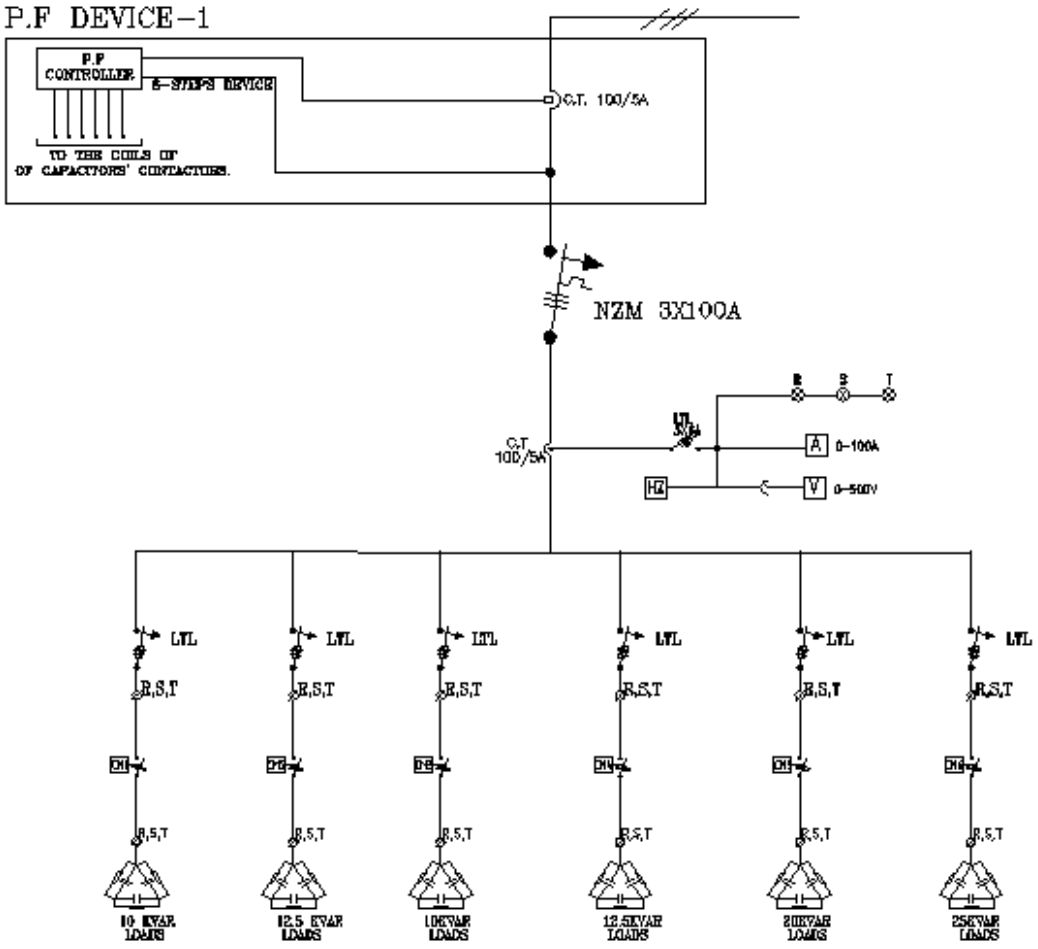


figure 1.7.5 a

1.8 Transformers ratings and wiring connections

Distribution transformer is used to convert electrical energy of higher voltage (usually 11-22-33kV) to a lower voltage (250 or 433V) with frequency identical before and after the transformation. Application of it is mainly within suburban areas, public supply authorities and industrial customers. With given secondary voltage, distribution transformer is usually the last in the chain of electrical energy supply to households and industrial enterprises.

1.8.1 parts in the distribution transformer:

1. Coils/winding – where incoming alternate current (through primary winding) generates magnetic flux, which in turn develop a magnetic field feeding back a secondary winding.
2. Magnetic core – allowing transfer of magnetic field generated by primary winding to secondary winding by principle of magnetic induction
3. Tank – serving as a mechanical package to protect active parts, as a holding vessel for transformer oil used for cooling and insulation and bushing (plus auxiliary equipment where applicable

First 2 parts are known as active parts.

1.8.2 Power Transformer Rating:

Tr.Rating(KVA)	Fuse Rating(A)	Instillation
50	10	Outdoor
100	10	Outdoor
160	15	Outdoor
250	15	Outdoor
400	25	Outdoor& indoor
630	35	Outdoor& indoor
800	40	Outdoor& indoor
1000	40	indoor
1250	63	indoor
1600	63	indoor
2000	63	indoor

- Air transformer

- ground transformer

Reference :

http://www.krk.com.tr/urunler_eng.asp?islem=detay&ID=16&aID=15&kID=28
http://www.annaichina.com/ArticleShow.asp?ArticleID=60
http://en.wikipedia.org/wiki/Digital_panel_meter
http://en.wikipedia.org/wiki/Electricity_meter

http://en.wikipedia.org/wiki/Power_factor
http://www.nepsi.com/kvar_calculation.htm
http://www.galco.com/circuit/harmon.htm
brary.abb.com/global/scot/scot292.nsf/.../$File/EPDdtr2.pdf
Lecture note.

Chapter 2

The Islamic university of Gaza

ENGINEERING FACULTY

Electrical engineering department

EELE5421

ELECTRIC BOARD

STUDENT NAME :

TAREK MAHER AL TALMAS

STUDENT # :

120050753

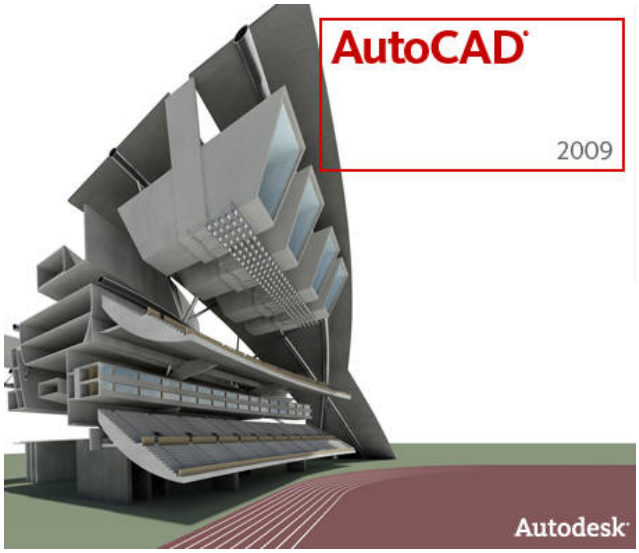
CHAPTER 2

Introduction to AutoCAD

Prof. Dr. Muhammed Abdelati

2009-2010

Introduction to AutoCAD



In this chapter we can talk about three topics:

2.1 AutoCAD tutorial: in this part we show how to use AutoCAD.

2.2 international protection (IP) rating: in this part we show the IP number that can at the devices and describe the device protection against the water and solid.

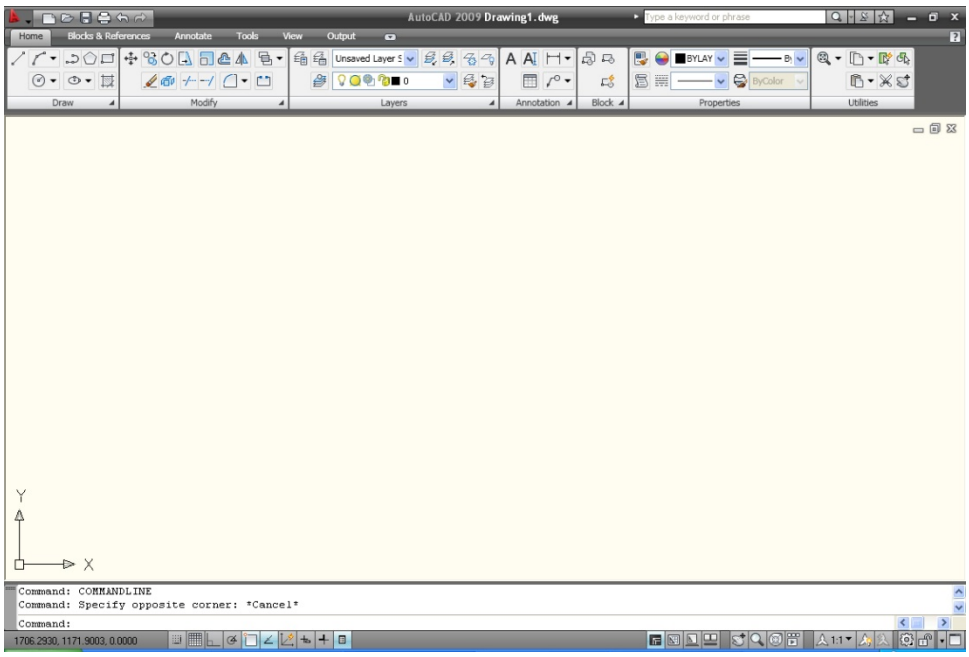
2.3 electrical symbols: in this part we show the electrical symbol of the electrical part that we can use it in AutoCAD design and this picture.

CHAPTER 2

2.1 - برنامج الاوتوكاد 2009

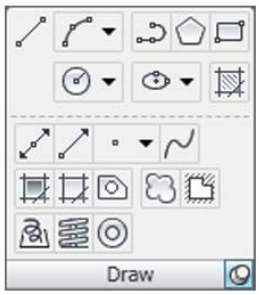
2.1.1 تعريف بشاشة أوتكاد:

يعتبر برنامج أوتكاد من أهم البرامج الرسومية والهندسية الذي يحتوي على الأبعاد الثنائية والأبعاد الثلاثية، ويوضح الشكل التالي الشاشة الرئيسية لبرنامج الأوتوكاد 2009 .

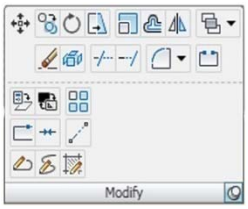


- **تتكون شاشة الأوتوكاد من :**

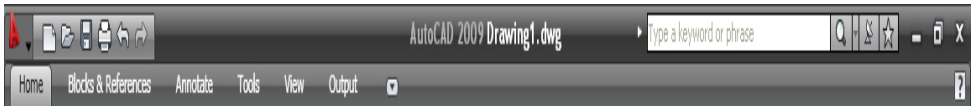
1. قائمة DRAW :شريط أدوات الرسم ويحتوي على مجموعة أزرار خاصة بالرسم .



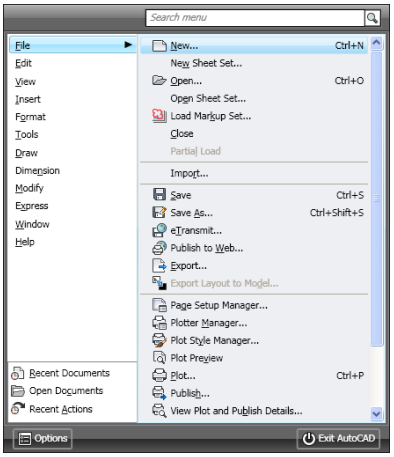
2. قائمة MODIFY: تستخدم في تعديل الرسم الموجود



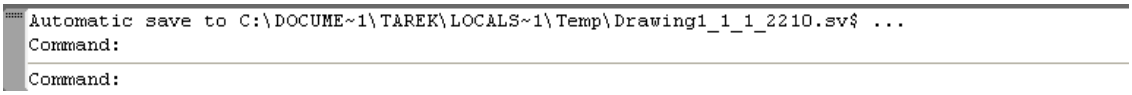
3. الشريط الموجود في رأس البرنامج والذي يحتوي على اسم الملف الذي نعمل فيه وأدوات اخرى نستفيد منها .



4. القائمة التي تحتوي على القوائم المنسدلة في البرنامج (.....FILE – EDIT-TOOLS)



5. شريط ادخال الأوامر والذي يستخدم لادخال الامر المراد تطبيقه وهي احدى الطرق لتطبيق اداة معينه .



تعليمات هامة :

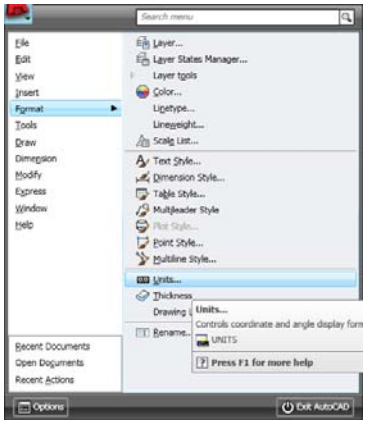
يجب علينا مراعاة التعليمات التالية لسهولة تنفيذ الأوامر في برنامج أوتوكاد وإعطاء نتائج دقيقة وصحيحة في العمل :

1- في حال تنفيذ أي أمر وأردنا فصل هذا الأمر نضغط زر Escape .

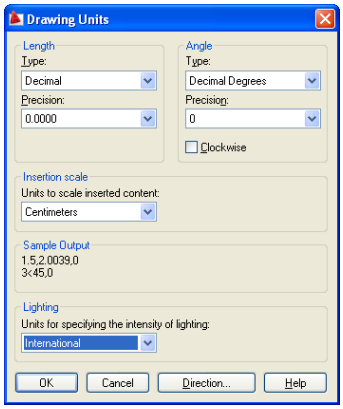
2- في حال إذا أردنا تكرار أي أمر تم استخدامه نضغط زر Enter حيث يظهر اسم الأمر في موجه الأوامر.

3- قبل البدء بعملية الرسم يجب ضبط وحدات الرسم وذلك كالتالي :

نضغط على حرف A باللون الاحمر في اعلى البرنامج << FORMAT << UNITS



يظهر لنا الشكل التالي : نضبط القيم كما هو موضح لتكون وحدة الرسم لدينا هي السانتيميتر .

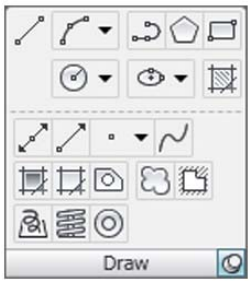


4- نضغط على F7 فنظهر النقط على الشاشة او نخفيها .

5- نضغط F8 لجعل رسم خطوط مستقيمه متعامده فقط على محوري X,Y .

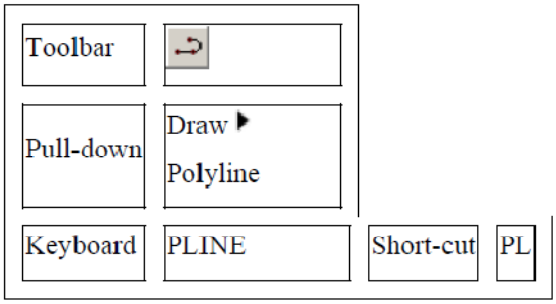
2.1.2 شريط ادوات الرسم (draw toolbar)

الشكل التالي يوضح شريط الأدوات المستخدمه في عملية الرسم فهو يحتوى العديد من الادوات سنقوم بشرح الادوات الاكثر استخداما عند مهندس الكهرباء .



- **أداة (polyline):** يختلف الـ polyline عن الـ line حيث انه يقوم بعدة وظائف منها تحديد سماكة الخط ورسم قوس وغيرها من المميزات .

نقوم باختيار هذه الأداة بواسطة احدى ثلاث طرق موضحه في الشكل التالي :



بعد اختيار الاداة نلاحظ ظهور جملة ي شريط الأوامر تطالبنا بتحديد نقطه بداية كما هو موضح .

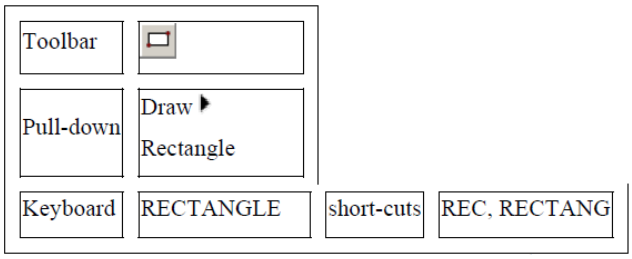
Specify start point:

نقوم باختيار اي نقطه في مساحه العمل فيظهر لنا التالي والذي يطالبنا اما بوضع النقطه الاخرى او القيام باحد الأوامر الموضحه في الشكل .

Specify next point or [Arc/Halfwidth/Length/Undo/Width).

Width: ويستخدم لتحديد سماكة الخط ويمكن تحديد سماكة بداية الخط ونهايته(اختصاره حرف W) .
Halfwidth: يستخدم هذا الأمر لإعطاء نصف قيمة السماكة لبداية الخط ,ونصف قيمة السماكة لنهايته (واختصاره الحرفH)
Length: يستخدم هذا الأمر لزيادة طول القطعة المستقيمة السابقة التي تم رسمها حسب قيمة معينة يتم إدخالها وعلى نفس الاستقامة (واختصاره الحرف L).
Undo: واختصاره الحرف U يستخدم هذا الأمر للتراجع عن آخر خط تم رسمه.
Arc: يستخدم في عملية رسم القوس (واختصاره A).

- **أداة (Rectangle)** : تستخدم لرسم مستطيل أو مربع (شكل يتكون من 4 أضلاع) ، نقوم باختيار هذه الأداة بواسطة احدى ثلاث طرق موضحه في الشكل التالي :



بعد اختيار الاداة نلاحظ ظهور جملة ي شريط الأوامر تطالبنا بتحديد الزاوية الأولى للمستطيل او الاختيار بين الاوامر التالية كما هو موضح .

Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]:

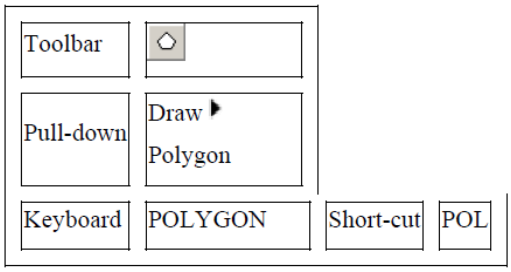
Chamfer: يستخدم هذا الأمر لإنشاء شطفة للمستطيل, يحدد طولها على المحور الأول وطولها على المحور الثاني بعكس دوران عقارب الساعة .(اختصاره C)
Elevation: يستخدم هذا الأمر لتحديد منسوب لهذا المستطيل (أي ارتفاع مستوي المستطيل على Z المحور) (اختصاره E)
Fillet: يستخدم هذا الأمر لتحويل زوايا المستطيل إلى أقواس دائرية (اختصاره F)
Thickness: يستخدم هذا الأمر لإعطاء سماكة للمستطيل على المحور z (اختصاره T)
Width: يستخدم هذا الأمر لتحديد سماكة لخطوط المستطيل (اختصاره W)

بعد اختيار الزاوية الأولى للمستطيل يظهر لنا الأمر التالي الذي يطالبنا باختيار الزاوية المقابلة او مساحة الكل او طوله او عملية التدوير له .

Specify other corner point or [Area/Dimensions/Rotation]:

Area: تستخدم لتحديد مساحة الشكل (اختصاره A)
Dimensions: يستخدم لتحديد طول الشكل (اختصاره D)
Rotation: يستخدم لتدوير الشكل بزاوية معينة (اختصاره R).

- **أداة (Polygon):** يعطي هذا ألأمر إمكانية رسم متعدد أضلاع من 3- 1024 ضلع ، و لذلك يجب تحديد عدد الأضلاع. ويمكننا استخدام هذه الاداة والوصول اليها بأحدى الطرق التالية .



بعد اختيار الأداة يطلب منا تحديد عدد الأضلاع ونلاحظ ان العدد الموجود مسبقا هو 4 أضلاع :

Enter number of sides <4>:

ثم يطلب تحديد مركز الشكل

Specify center of polygon or [Edge]:

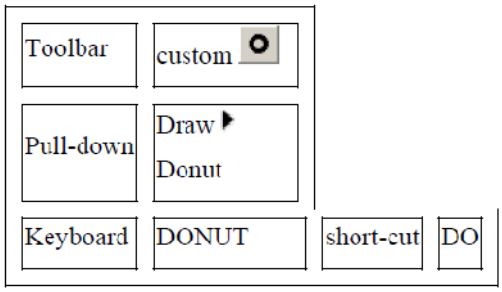
ثم يطلب تحديد ان كانت الدائرة الوهمية التي تمس الشكل تمسه من الداخل او الخارج.

Enter an option [Inscribed in circle/Circumscribed about circle] <I>:

ثم يطلب من تحديد نصف قطر الدائرة

Specify radius of circle: (pick P2 or enter exact radius)

- **الأداة (Donut) :** تستخدم لرسم دائرة بسمك معين لها نصف قطر داخلي واخر خارجي ونختار الأداة باحدى الطرق التالية .



بعد اختيار الاداة يطالبنا باختيار قطر الدائرة الداخلي

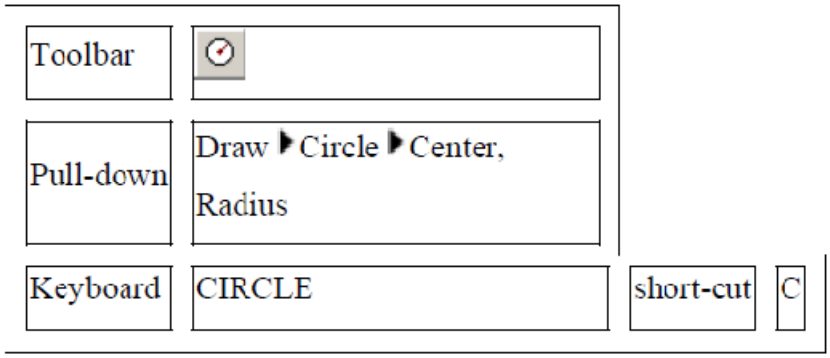
Specify inside diameter of donut <0.5000>:

ثم يطالبنا باختيار القطر الخارجي

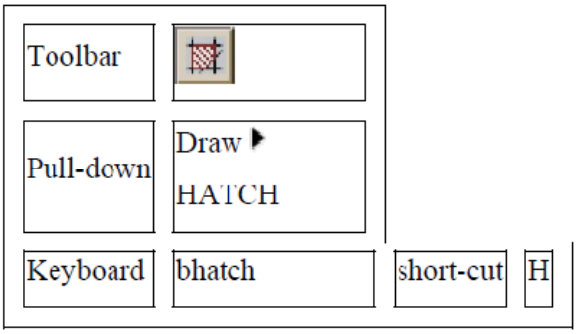
Specify outside diameter of donut <1.0000>:

نقوم بكتابة كلا القطرين صم نضغط enter ونضغط بمؤشر الماوس على المكان الذي نريد وضع الشكل الناتج فيه .

- **أداة (circle):** تستخدم لرسم الدائرة وعند اختيارها يطلب منا تحديد مركز الدائرة ثم تحديد قطر الدائرة او نصف قطرها نختار هذه الاداة عن طريق التالي.

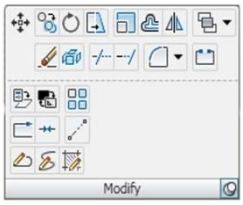


- أداة (HATCHING): تستخدم لعمل تهشير على الشكل المرسوم نصل اليها باحد الطرق التالية الموضحه ادناه .



2.1.3 شريط أدوات التعديل(modify)

الشكل التالي يوضح شريط الادوات المستخدم في التعديل على الرسومات الموجودة في شاشة الرسم.



❖ **الأمر (MOVE) :**

يستخدم لتحريك الاشكال على مساحة العمل ونتعامل مع الامر كالتالي .

- نقوم باختيار الامر من قائمة الأدوات فيظهر لنا التالي .

```
Command: m
MOVE
Select objects:
```

- ثم نختار الشكل المراد تحريكه ونضغط زر enter فيظهر لنا التالي.

```
Select objects: Specify opposite corner: 1 found
Select objects:
Specify base point or [Displacement] <Displacement>:
```

- ثم نضغط على اي نقطة في الشكل المراد تحريكه حسب ما نرى في الصورة السابقة فيظهر لنا التالي .

```
Select objects: Specify opposite corner: 1 found
Select objects:
Specify base point or [Displacement] <Displacement>: Specify second point or <use first point as displacement>:
```

- من الشكل السابق يطلب من النقطه المرد تحريك الشكل لها او نقوم عن طريق الماوس بتحريك الشكل الى المكان الذي نريد .

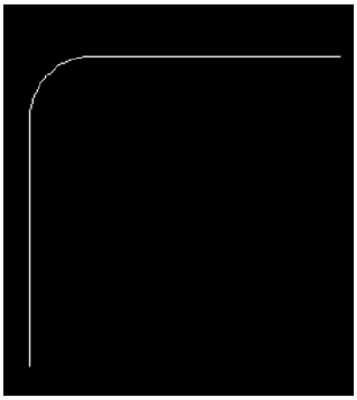
❖ **الامر (copy):** يستخدم لعملية انشاء نسخه من شكل معين . تطبيق هذه الأمر يشابه تماما عملية تطبيق امر التحريك الذي سبق شرحه .

❖ **الأمر (erase):** يستخدم لمسح العناصر المرسومة المختارة ،عند اختيار الامر يطلب منا البرنامج اختيار الشكل المراد مسحه فنختاره ثم نضغط enter فيمسح الشكل .

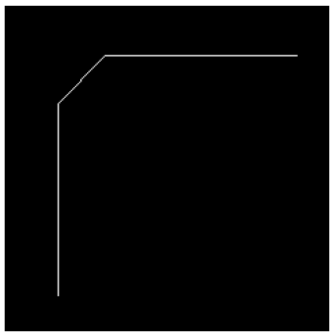
❖ **الأمر (TRIM)**: لو أردنا ازالة الجزء رقم 1 من الشكل المقابل نستخدم هذه الأداة وذلك بختيار الأداة ثم نختار القطعه رقم 2 ثم نضغط enter ثم نضغط على القطعه رقم 2 ليصبح ليدنا الشكل التالي .

❖ **الأمر(EXTEND):** لو أردنا وصل القطعه الأفقية لتصل الى القطعه الطولية بدون اي زيادة عن طريق هذه الاداة وذلك باختيار الأداه ثم الضغط على القطعه الطولية ثم enter ثم الضغط على القطعه الافقية .

❖ **الأمر(FILLET): يجعل منطقة التقاء الخطين المستقيمين بدل زاوية الى قوس دائري .**



❖ **الأمر(CHAMFER): يجعل منطقة التقاء الخطين المستقيمين بدل زاوية الى خط مائل .**



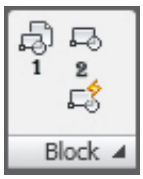
❖ **الأمر(EXPLODE):** يستخدم هذا الأمر لتفتيت شكل ما وارجاعه الى مكوناته الأصلية مثال المستطيل يصبح 4 اضلاع يمكن التحكم في كل منها على حدا .

❖ **الأمر(SCALE):** يستخدم لتكبير او تصغير شكل ما وذلك بعد اختيار الاداة ثم نختار الشكل المراد تصغيره او تكبيره ثم نضغط enter ثم بمؤشر الماوس نضغط على اي نقطه في الشكل المراد التعامل معه ثم نضع قيمة التكبير او التصغير فلو وضعنا 2 ثم ضغطنا enter يتضاعف حجم الشكل ولو وضعنا .5 ثم enter يتقلص حجم الشكل الى النصف .

❖ **الأمر (ROTATE): يستخدم هذا الأمر من أجل تدوير العناصر المختارة حول نقطة معينة وبزاوية معينة .حيث بعد اختيار الأداة يطلب من اختيار الشكل المراد تدويره ثم نضغط ENTER ثم نختار اي نقطه على الشكل لتكون محور الدوران ثم نكتب الزاوية التي سيدور فيها الشكل .**

❖ **الأمر(MIRROR): يستخدم هذا الأمر من أجل صنع مرآة (انعكاس) للعنصر المختار .**

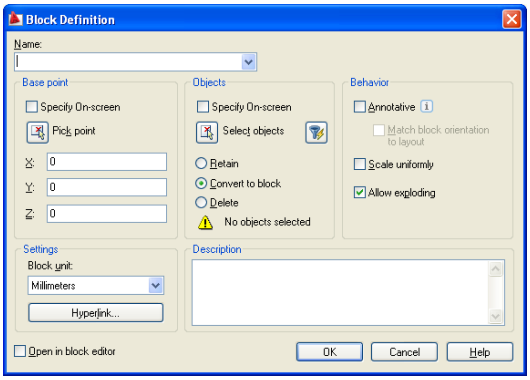
2.1.3 شريط أدوات البلوك (BLOCK)



حسب الصورة السابقة نلاحظ ان الادة التي تحمل الرقم واحد هي INSERT والاداة التي تحمل رقم 2 هي CREAT .

- **CREAT:** لو افترضنا ان لدينا شكل يتكرر استخدامه نقوم بعمل BLOCK بحيث لا نعيد رسمه انما ندرجه عن طريق الأمر INSERT.

ولاستخدام الامر CREAT نقوم اولا بالضغط على الايقونة رقم 2 فتظهر لنا الرسالة التالية :



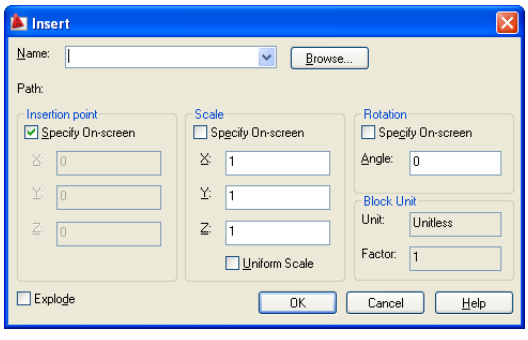
فنقوم بالضغط على الايقونة بجانب SELECT OBJECTS لاختيار الشكل المراد ثم نضغط ENTER .

ثم نضغط على الأيقونة بجانب PICK POINT لاختيار النقطه التي عند ادراج الشكل سيكون المؤشر عليها .

ثم نكتب اسم الشكل في الاعلى ونضغط OK .

ولادراج شكل سابق عن طريق الأيقونة رقم 1 (INSERT):

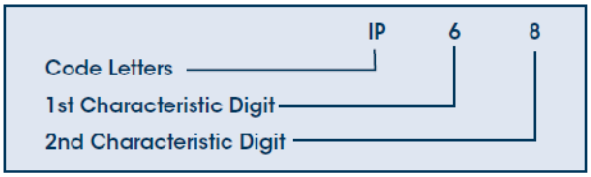
وذلك باختيار الايقونة فتظهر لنا الشاشة التالية :



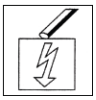
من القائمة المنسدلة نختار احد الرموز المحفوظة سابقا ثن نضغط OK .

2.2 - IP (Ingress Protection) Ratings

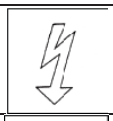
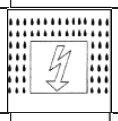
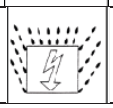
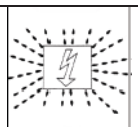
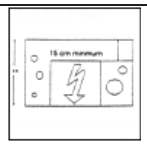
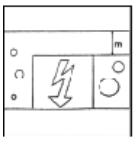
An IP Rating or IP Code is an international numerical standard used to classify the degree of protection provided against the intrusion of solid objects and water in electrical enclosures. This standard provides users with a more detailed explanation for products other than the vague term ‘waterproof.‘ The IP rating is listed as ‘IP’ followed by two digits. The first digit indicates a protection level against solid objects such as dust, and the second digit indicates the degree of protection against the ingress of water. The lower the number the lower the protection and the higher the number the harsher environment the item can withstand.



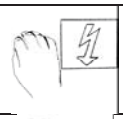
- **First digit**

DIGIT	Object size protected against	SYMBOLE
0	No protection against contact and ingress of objects	
1	Protected against solid objects over 50mm, e.g. accidental touch by hands	
2	Protected against solid objects over 12mm, e.g. fingers.	
3	Protected against solid objects over 2.5mm, e.g. tools and wires.	
4	Protected against solid objects over 1.0 mm, e.g. tools and small wires.	
5	Protected against dust – limited ingress (no harmful deposits).	
6	Totally protected against dust	

- **Second Digit**

DIGIT	Object size protected against	SYMBOLE
0	No Protection	
1	Protected against vertically falling drops of water, e.g. condensation.	
2	Protected against direct sprays of water up to 15o from the vertical	
3	Protected against sprays of water up to 60o from the vertical.	
4	Protected against water sprayed from all directions - limited ingress	
5	Protected against low pressure jets of water from all directions - limited ingress permitted.	
6	Protected against strong jets of water, e.g. for use on ship decks.	
7	Protected against the effect of immersion between 15cm and 1.0 m.	
8	Protected against long periods of immersion under pressure	

- **Protection against Mechanical Impact:**

DIGIT	Object size protected against	SYMBOLE
A	Protection against access with the back of a hand.	
B	Protection against access with a finger.	
C	Protection against access with a tool of 2.5mm or larger and up to 100mm long.	
D	Protection against access of a wireof 1mm dia or larger and up to 100mmlong.	

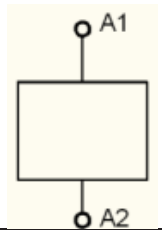
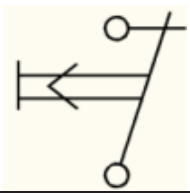
2.3 - Electrical symbols :

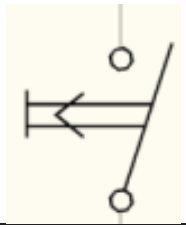
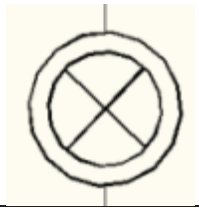
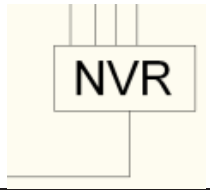
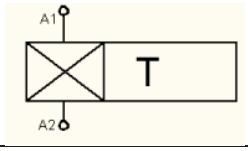
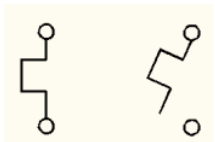
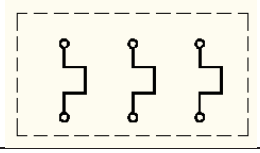
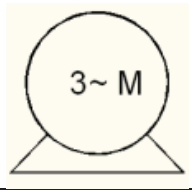
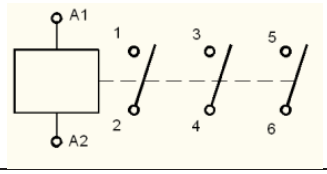
❖ Introduction:

In this part we can talk about the electrical symbols that we can use it in the AutoCAD design for the building and power and control circuits.

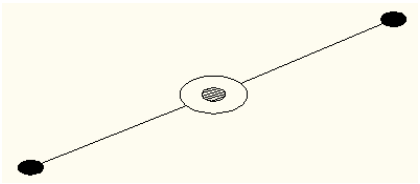
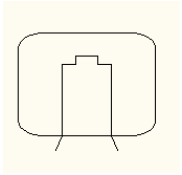
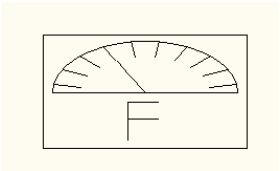
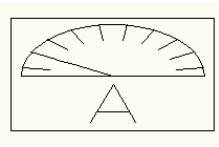
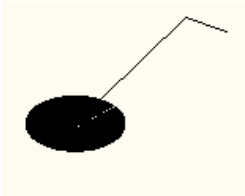
Such as (circuit breakers, contactor, NVR's, motor...etc)

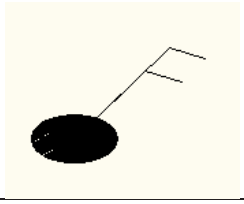
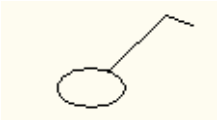
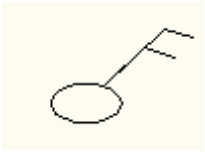
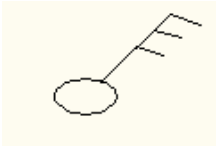
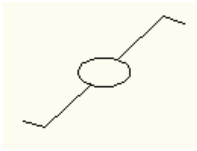
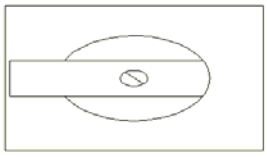
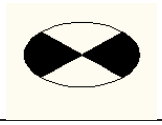
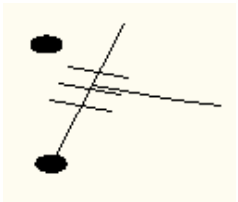
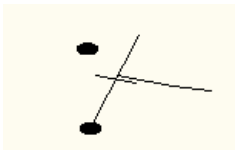
- **First we can talk about the symbols that we can use it in control circuits and power circuits.**

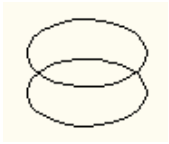
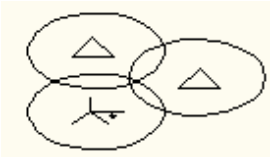
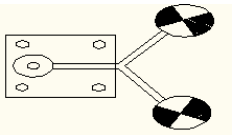
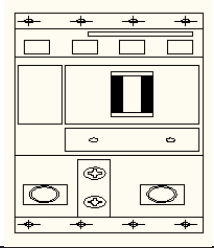
The symbol	The name
	The coil of contactor or relays.
	Normally open contact for relay or contactor.
	Normally close contact for relay or contactor.
	Normally close contact for BUSH BOTTON.

	Normally OPEN contact for BUSH BOTTON.
	Indicator lamp
	NVR: device that detect the 3phase sequence.
	The coil of the timer.
	N.C. and N.O. contact of overload.
	Over load
	3phase device (motor ,pumb)
	Contactor

- **Second we can talk about the symbols that we can use it in design the buildings map.**

The symbol	The name	Picture
	400v 4 pole manual change over	
	22kv HRC fuse	
	45-55 frequency meter	
	5A analogue ammeter	
	Current transformer	
	One gang one way switch with water tight plate. Ip55	

	Two gang one way switch ip55 water tight plat	
	One gang one way	
	Two gang one way	
	Three gangs one way switch	
	One gang two way switch	
	220/24 selector switch	
	220/24 v signal lump	
	3-phase circuit breaker	
	1-phase circuit breaker	

	One phase isolating transformer	
	Delta/star delta distribution transformer	
	Digital power factor controller with lcd	
	Digital power multimeter set	
	Double armed light pole	
	4-POLES MOULDED CASE CIRCUIT BREAKER.	
	SUB- MAIN DISTRIBUTION BOARD.	

Islamic University - Gaza
Faculty of Engineering
Electrical Engineering Department

Electrical boards course

Lecture note

Chapter 3

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Forward:

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Professor of Electrical & Computer Engineering
Islamic university-Gaza

Sunday, December 27, 2009

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Chapter 3

Soft starting of three phase motors using RVS-DN

3.1 Introduction:

An induction motor is an energy conversion device, converting electrical energy into mechanical energy and some heat energy, for an induction motor, torque is proportional to the motor terminal voltage squared(V2). So, for example, half the voltage produces a quarter of the torque.

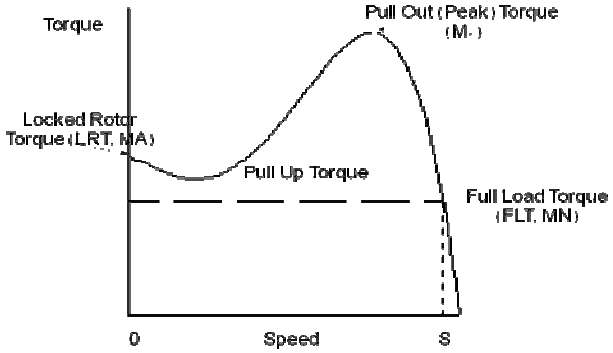


Figure (3.1) speed current curve

Because the load starting torque is usually near zero, an induction motor will develop far too much torque when connected directly to the supply. So, at the instant of start-up, there is an un-necessary heavy power surge on both the electrical supply and the mechanical drive components.

3.1.1 Start induction motor methods:

Direct-On-Line Starters

This type of starter is the simplest means of controlling energy flow to an induction motor and it relies on a single, 3-phase switch, known as a contactor to interrupt the power supply to the motor.

Very widely applied, the method is known variously as "direct-on-line", "across-the-line", "direct" etc., and is the usual form of control where low cost is the first, and most important consideration.

As a result, it is most often used on small motor sizes up to 10 Hp or so, or where the supply is strong enough to withstand the inrush and starting current surges without causing unacceptable voltage drops.

Star-Delta Starters

Reduced voltage starting makes use of the fact that motor torque is proportional to the square of the terminal voltage, and the most familiar type of reduced-voltage starter is the star-delta starter.

Consisting of three contactors and a time switch, the star-delta starter changes the motor winding configuration from an initial star connection to a delta as the motor accelerates. The change-over or transition point is controlled by the time switch and is usually arranged to be approximately at 80% of full speed.

The effect of starting in star is to place the phase voltage across the stator windings which is equivalent to 58% of the line voltage. Because of the square-law relationship mentioned earlier, this reduces the starting torque to a third of locked rotor torque (LRT) with a consequent reduction in starting currents and acceleration forces.

Semiconductor Motor Controller

During the 1950's, much effort was put into the development of a four-layer transistor device which had the power to switch large currents at high voltages when triggered by a very small pulse of current. This device became known as the silicon controlled rectifier (SCR), or in Europe, the 'Thyristor'; it is the basis on which all soft starting systems are built. The characteristic of most interest is the ability of the thyristor to switch rapidly (in about 5 millionths of a second) from "OFF" to "ON" when pulsed, and to remain "ON" until the current through the device falls to zero, - which conveniently, happens at the end of each half-cycle in alternating current supplies.

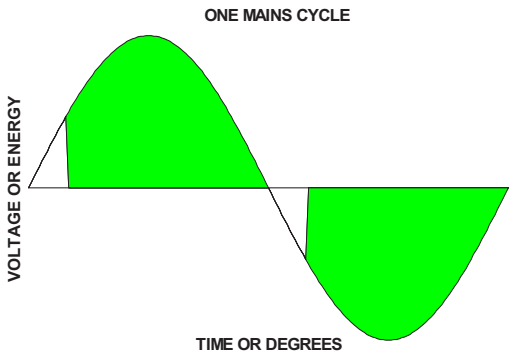


Figure (3.2) thyristor output

By controlling the switch-on point of a thyristor relative to the voltage zero crossing in each half wave of an alternating current, it is possible to regulate the energy passing through the device-see figure (2)-. The closer the turn-on point is to the voltage zero crossing point, the longer the energy is allowed to flow during the half-cycle. Conversely, delaying the turn-on

point reduces the time for the energy to flow. Putting two thyristors back-to-back (or anti-parallel) in each of the phase connections to a motor-see figure (3.3)-, and by precisely controlling their turn-on points, an electronic soft starter continuously adjusts the passage of energy from the supply so that it is just sufficient for the motor to perform satisfactorily.

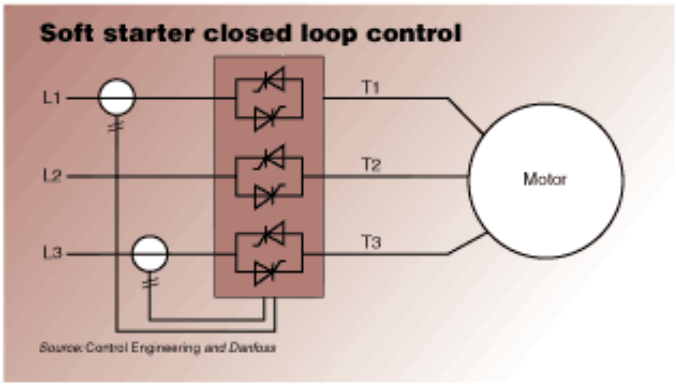


Figure (3.3) thyristor connection in softstarter

A motor soft starter is a device used with AC electric motors to temporarily reduce the load and torque in the powertrain of the motor during startup. This reduces the mechanical stress on the motor and shaft, as well as the electrodynamic stresses on the attached power cables and electrical distribution network, extending the lifespan of the system.

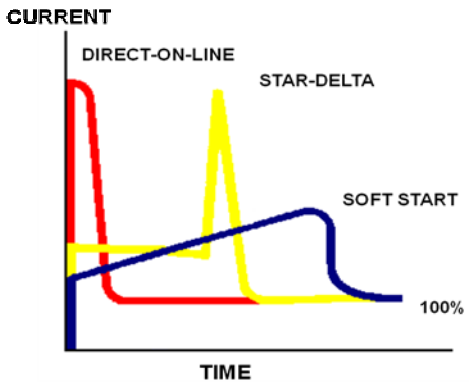


Figure (3.4) starting current for different start method

Note: Motor soft starters can consist of mechanical or electrical devices, or a combination of both. Mechanical soft starters include clutches and several types of couplings using a fluid, magnetic forces, or steel shot to transmit torque, similar to other forms of torque limiter.

RVS_DN soft starter:

The RVS-DN is a highly sophisticated and reliable soft starter designed for use with standard three-phase, three-wire and six-wire, squirrel cage induction motors. It provides the best method of reducing current and torque during motor starting.

The RVS-DN starts the motor by supplying a slowly increasing voltage to the motor. This provides soft start and smooth, stepless acceleration while drawing the minimum current necessary to start the motor.

3.2 standard wiring

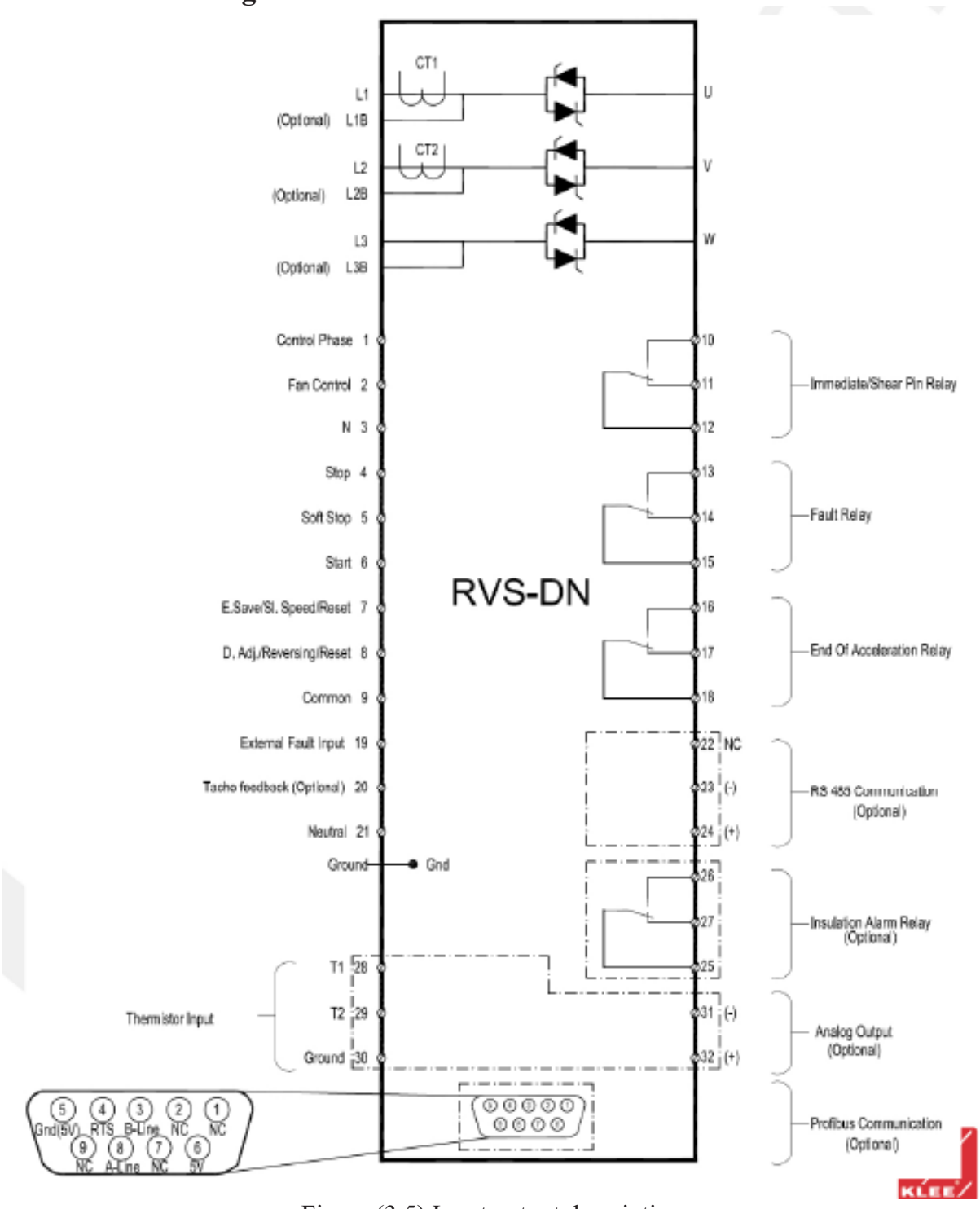


Figure (3.5) Input output description

Important input/output description:

Terminal 4: Input – STOP command.
• Input from a N.C. contact

• To stop the motor, disconnect Control Input voltage from terminal 4 for at least 250mSec. (no SOFT STOP).

Terminal 5: Input – SOFT STOP command.
• Input from a N.C. contact
• To SOFT STOP the motor disconnect Control Input voltage from terminal 5 for at least 250mS

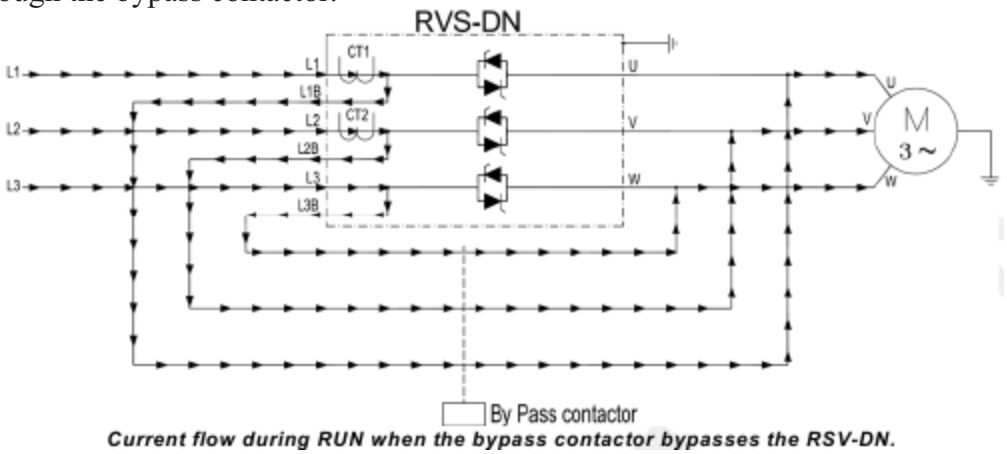
Terminal 6: Input – START command.
• Input from a N.O. contact.
• To SOFT START the motor, connect Control Input voltage to terminal 4 for at least 250mSec.

Terminal 13,14and 15: Programmable Fault output relay.

Terminal 18: Programmable End of acceleration (RUN) output relay

Bypass Contactor

Under normal operating conditions the heat dissipated by an RVS-DN causes heating of the enclosure and energy losses. The heating and losses can be eliminated by the use of a bypass contactor, which bypasses the RVS-DN after completion of start-up so that motor current will flow through the bypass contactor.



Current flow during RUN when the bypass contactor bypasses the RSV-DN.

Figure (3.6)

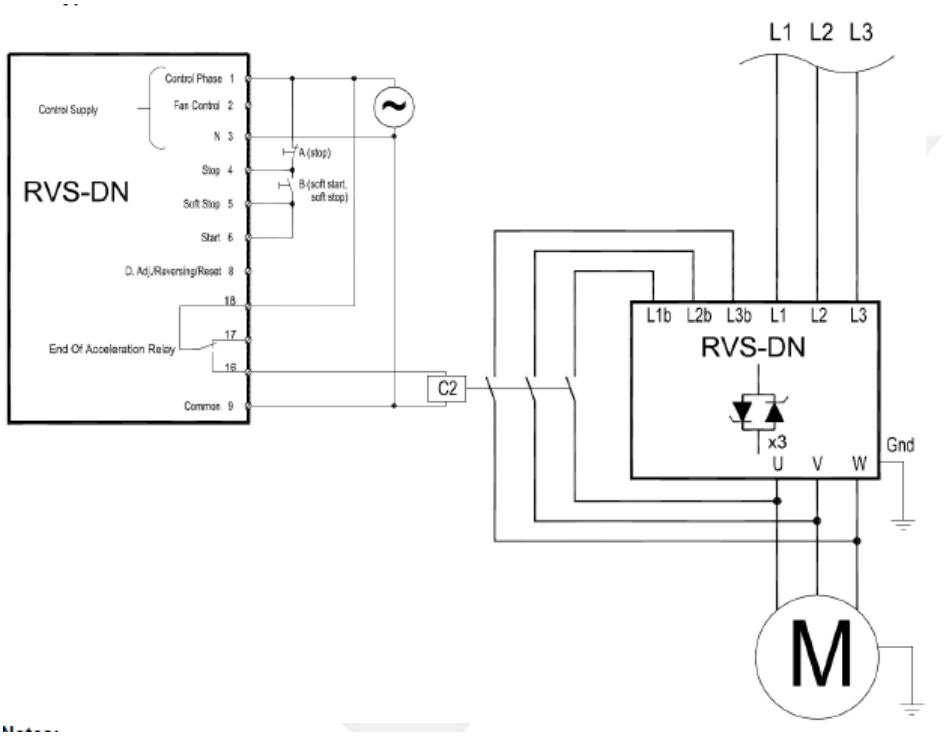


Figure (3.7) standard wiring

3.3 Direction control

Reversing with Two Line Contactors

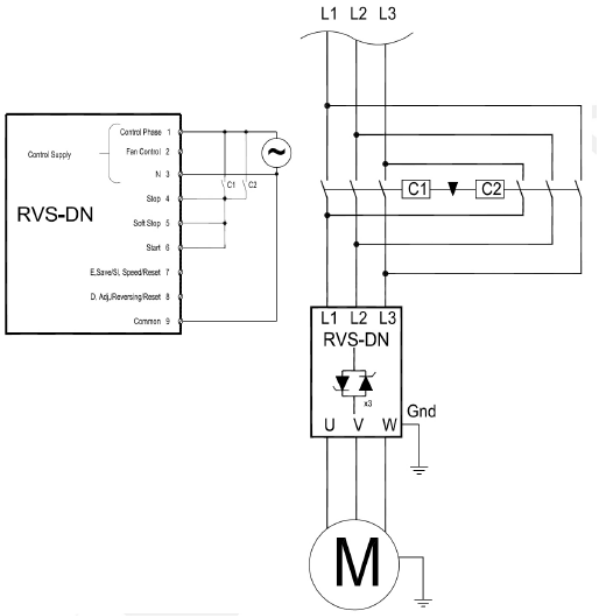


Figure (3.8): reversing motor direction power circuit

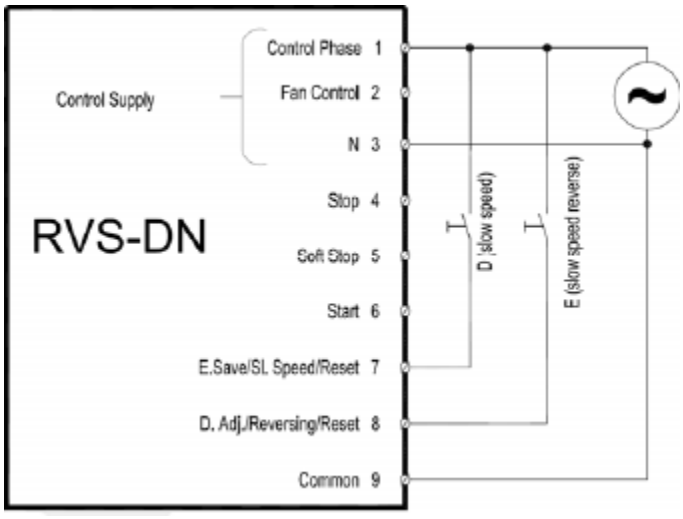
Notes:
• A N.O. auxiliary contact in each of the two line contactors C1 & C2 controls the START/STOP command. Closure of either contactor will supply main power and a start signal to the RVS-DN.
• It is recommended to employ a mechanical interlock between the forward and reverse contactors.
• It is required to delay the transfer between opening of one contactor and closing of second contactor.
• PHASE SEQUANCE fault must be disabled to operate reversing contactors at the line input of the RVS-DN.

Reversing via Input Terminal 8:

When SLOW SPEED REVERSE function is selected - connect Control Input voltage to terminal 8 to reverse direction. In order to operate in SLOW SPEED REVERSE, terminal 7 must be programmed as SLOW SPEED and Control Input voltage must be connected to terminal 7 as well. You can give the reverse command before the motor is started or during operation at SLOW SPEED. Connecting Control Input voltage to terminal 8 before motor is started, starts the motor in reverse direction. Connecting Control Input voltage while motor is running at SLOW SPEED stops the motor for 0.6 – 2 sec (according to motor size) before reversing its direction.

For Slow speed reverse operation:

o Program Input terminal 7 as SLOW SPEED.
o Program Input terminal 8 as SLOW SPEED REVERSE.
o Connect Control Input voltage to terminal 7 and start the soft starter. Motor will run at SLOW SPEED. When Control Input voltage is connected to terminal 8 motor will stop and SLOW SPEED REVERSE.
o If Control Input voltage is connected to terminal 8 before start command, motor will run at SLOW SPEED REVERSE when the start command is initiated.



Figure(3.9)

3.4 Inside Delta connection:

When the RVS-DN is installed Inside Delta, the individual phases of the RVS-DN are connected in series with
the individual motor windings (6 conductor connections as with the star-delta starter). The RVS-DN must only
conduct about 58 % (=1\√3) of the rated motor current. This allows the use of a significantly smaller RVS-DN.
For example :
For a motor with a rated current of 870A motor, a 950A starter will be selected to operate In-Line .For Inside Delta RVS-DN, we calculate (870 x 67% = 580A) and select a 580A starter.

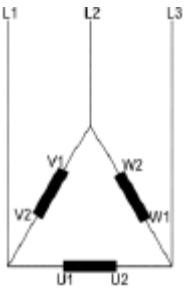


Figure (3.10): motor connection without RVS-DN

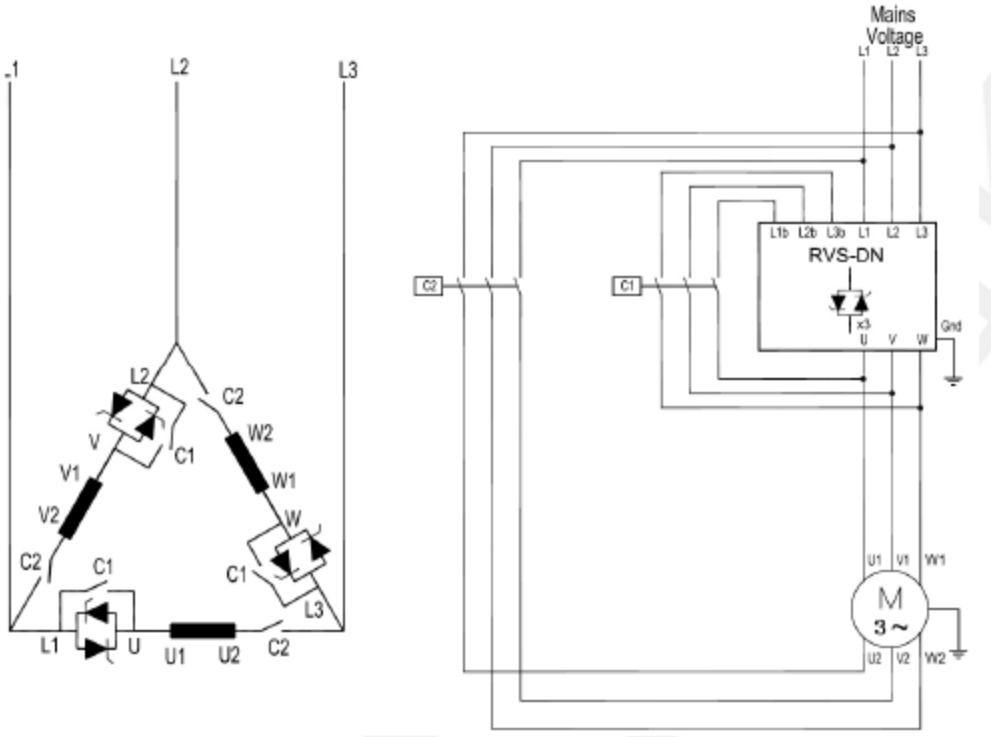


Figure (3.11): RVS-DN connection Inside Delta with bypass contactor to the RVS-DN and Inside Delta contactor.

C1 is a bypass contactor.
C2 is an Inside Delta contactor.
U1-U2, V1-V2, W1-W2 are motor windings.
L1-U, L2-V, L3-W are RVS-DN controlled phases.
L1b, L2b, L3b are preparation for bypass to maintain current protection when the RVS-DN is bypassed.

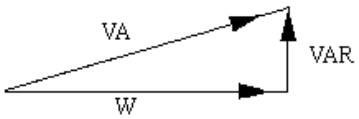
If speed reversing is required, L1, L2 and L3 on the input of the RVS-DN cannot be switched!
This is because PHASE SEQUENCE OFF cannot be implemented when RVS-DN is connected Inside Delta. Thus, in order to reverse motor rotation two motor windings need to be switched.

3.5 Power factor correction capacitor bank:

In an electric power system, a load with low power factor-as electric pump- draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor, to solve this problem capacitor banck added with load to increase power factor nearly=1.

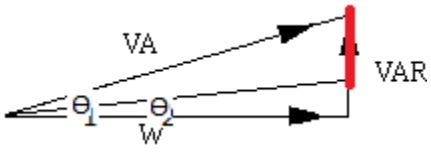
$$S = P + Q$$

S=apparent power (VA)
P=real power (W)
Q=reactive power (VAR)



So the mission is to decrease Q and increase P , new shape of power triangle as shown below

Assuming we want to decrease Q in the amount shown in figure below so



$$Q = P(tan\theta 1 - tan\theta 2)$$

$$Q = \frac{V2}{Xc}, \qquad C = \frac{1}{2\pi f Xc}$$

It's preferred to connect power factor correction (P.F.C) bank before soft starter device through contractor that energized after end of acceleration time because soft starter is designed to work with inductive load only.

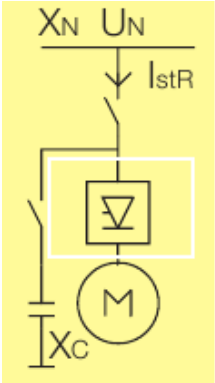


Figure (3.12) capacitor bank connection

Note: In case power supply source is generator there is no need to connect soft starter because when motor connected to generator voltage drop happen instantaneously then voltage back to increase softly so we can say that generator work as soft starter for motor.

3.6 Analysis of the power circuit of a water pump board

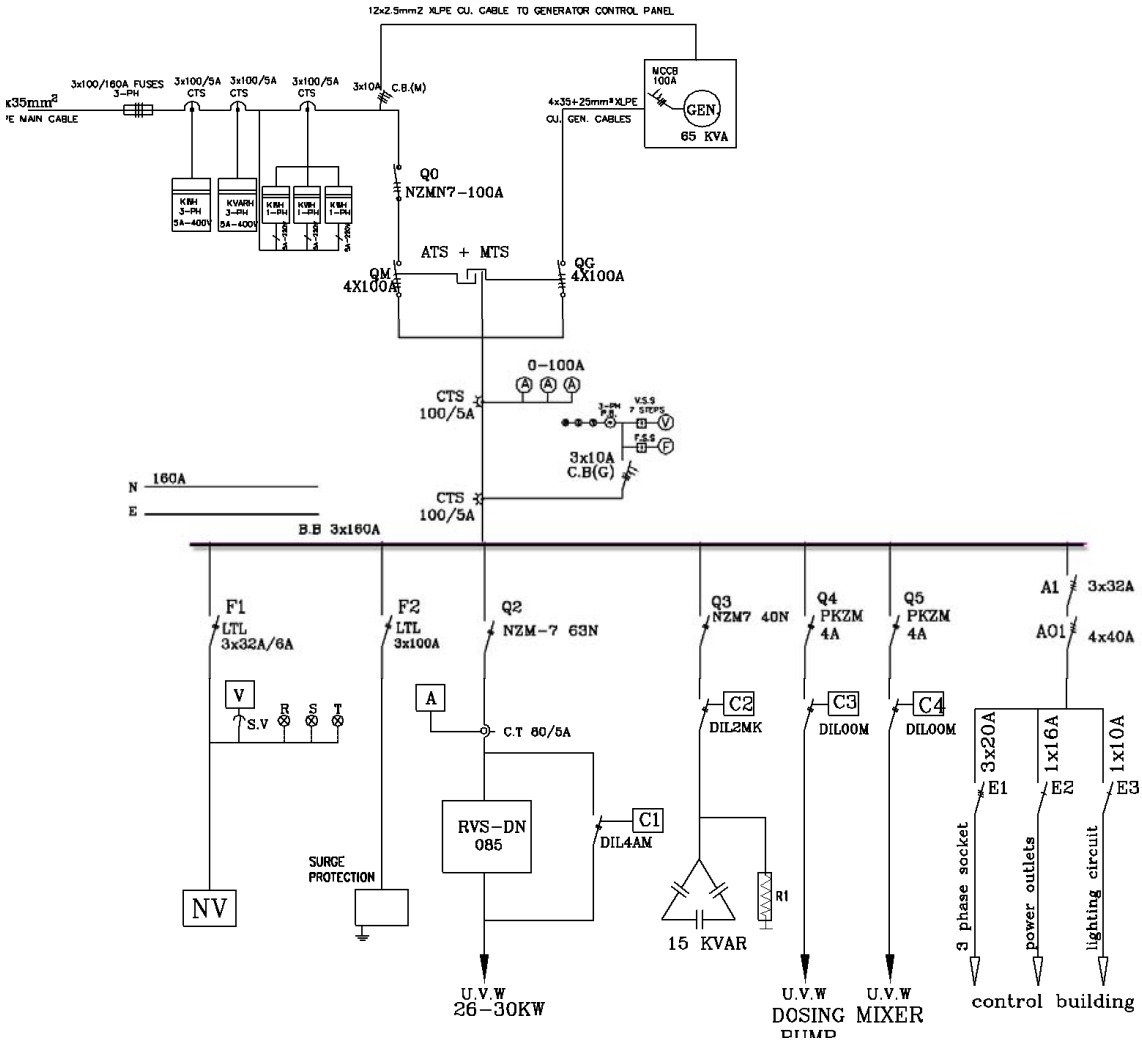


Figure (14) power circuit of a water pump board

Source:

To grantee continuity of electrical power to pump normally there are to source main source from subscription line and auxiliary from generator ATS & MTS used to change the source.

RVS_DN

In large pump more than 4hp soft starter used to start pump and protect it against high starting current, overload and other stuck, normally in RVS-DN connection NZM circuit braker install before RVS-DN for protection and on off control and bypass contactor C1for soft starter connection.

Capacitor bank

Used for power factor correction for pump normally work at the end of acceleration process in soft starter via C2.

Auxiliary loads

For different loads in building.

Dosing pump & mixer

Used to add chemical material to water for filtration and other things C3&C4 control it process timers or PLC used to control C3 & C4.

3.7 Programming

3.7.1 Hardware programming

Dip Switch Settings on the Main PCB

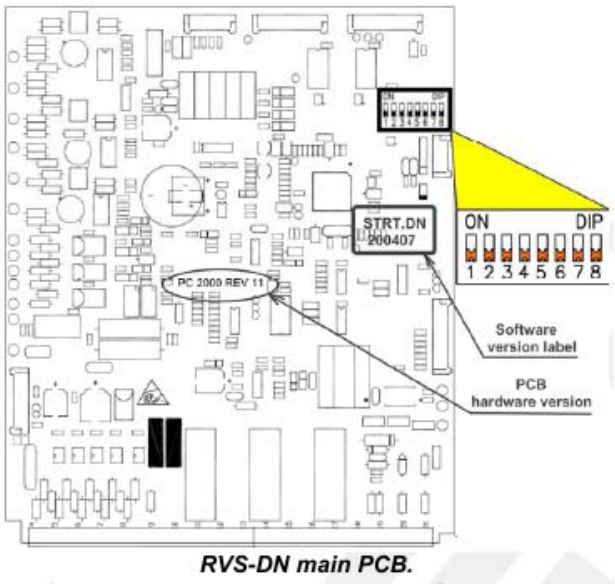


Figure (3.13)

The dip switch has eight separate switches. It is located under the front cover of the control module (in sizes B-F) or under the display unit (in size A).

No.	Switch Function	Switch Off	Switch On
1	Display format	Minimized	Maximized
2	Tacho feedback	Disabled	Enabled
3	Mains/generator	Mains	Generator
4	Must be off	-	-
5	LCD language selection	See tables below section 6.5.4 page 57.	
6			
7	Expanded settings	Disabled	Enabled
8	Software lock	Open	Locked

Most important switch for user switch 1 and 7 that I described below for more information about another switch back page 56 in user manual.
Switch # 1 – Display Modes
Two display modes are available:
Maximized – display of all possible parameters.
Minimized – display of pre-selected parameters.
Setting switch # 1 to off will minimize the LCD displays.

Maximized Mode - Switch #1 – On Minimized
Display only
Main parameters
Start parameters
Stop parameters
Dual adjustment
Energy save & slow speed parameters
Fault parameters
I/O programming
Communication parameters
Statistical data

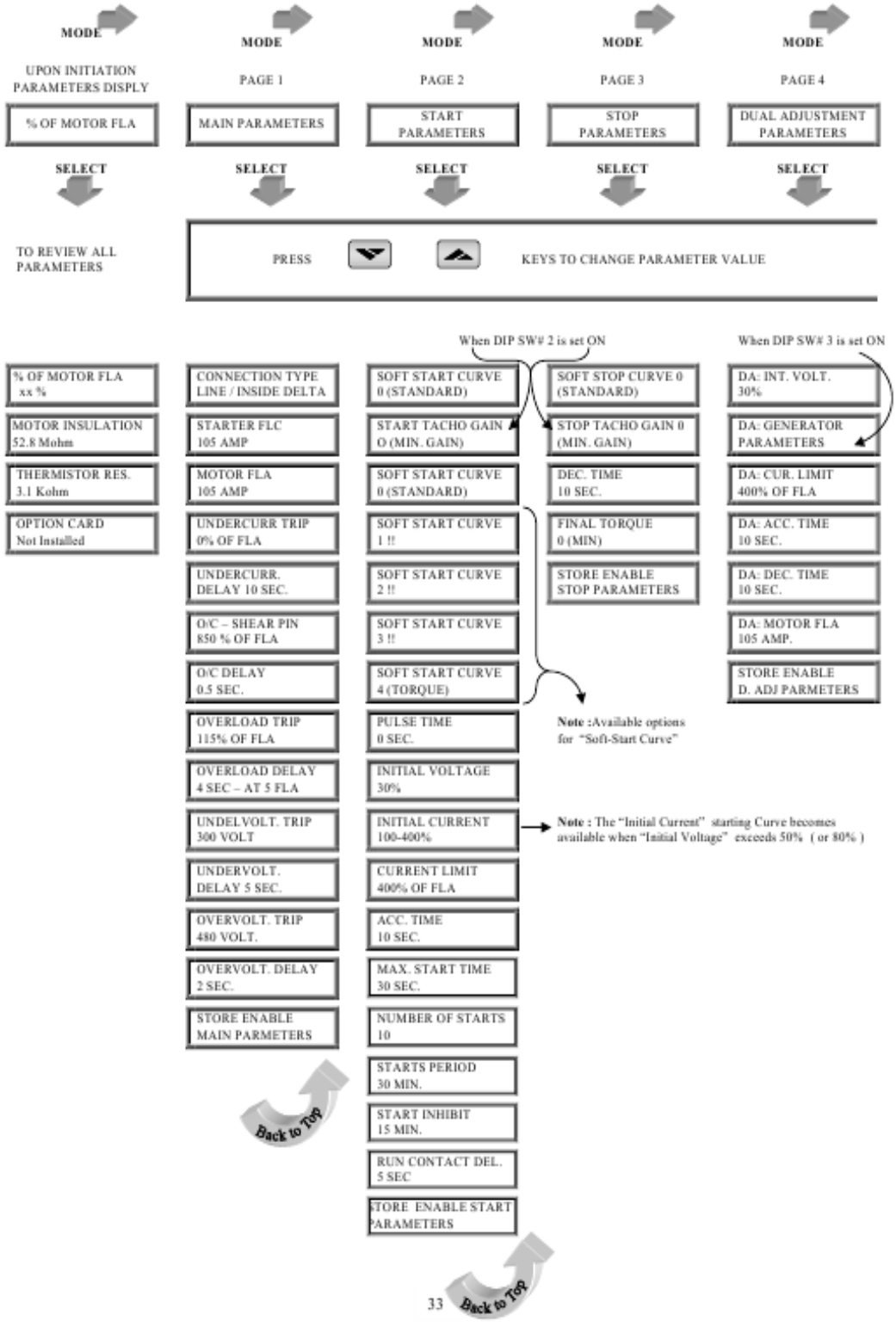
Mode Switch #1 – Off
Display only
Main parameters
Start parameters
Stop parameters
Statistical data

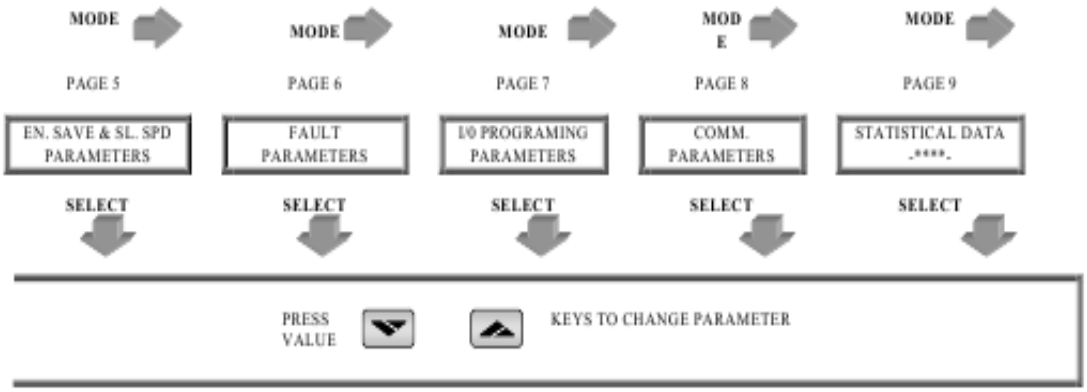
Switch # 7 – Expanded Settings
EXPANDED SETTINGS corresponds to:

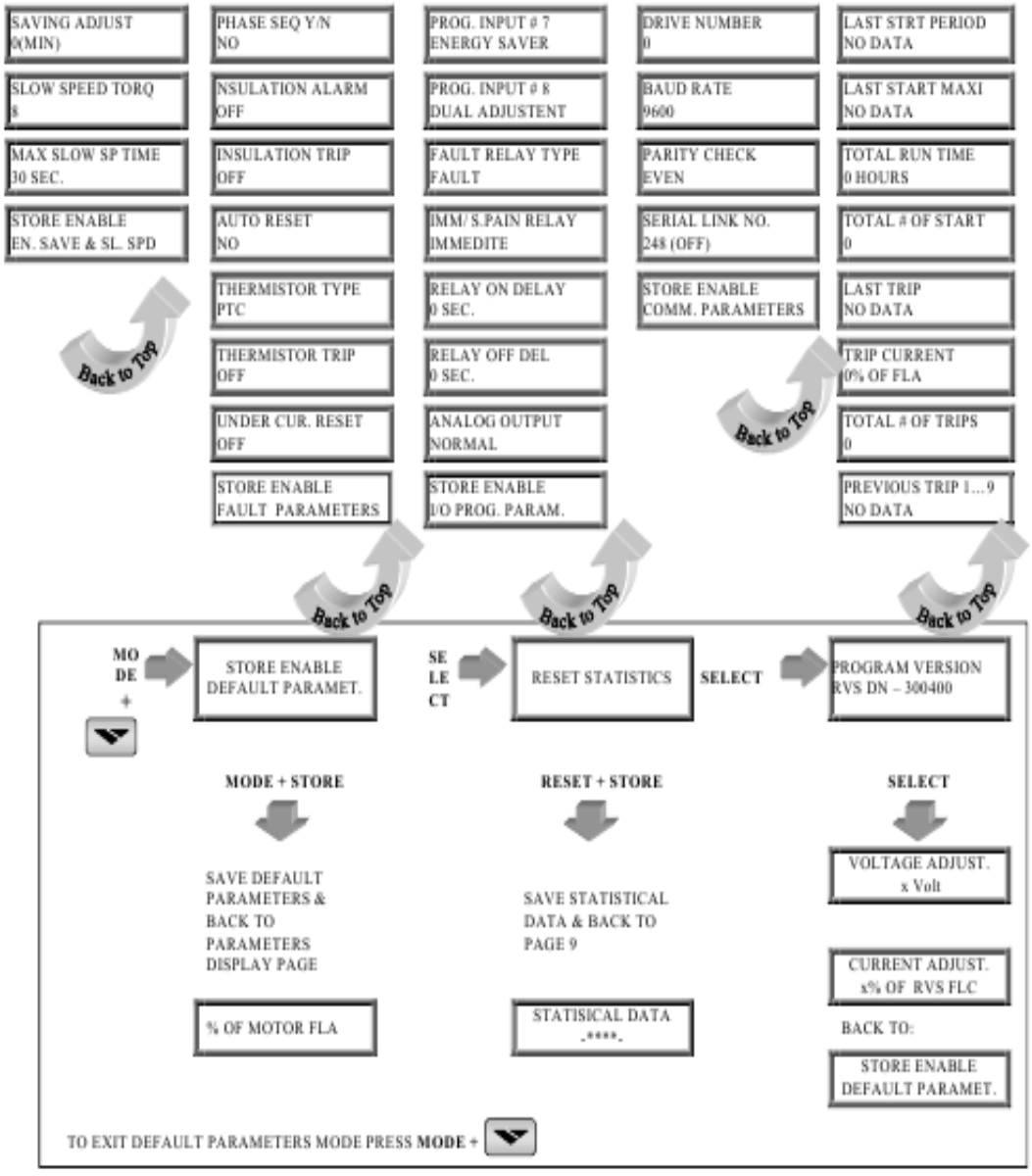
Parameter	Dip switch #7 - Off	Dip switch #7 - On
INITIAL VOLTAGE	10-50%	5[1]-80%
CURRENT LIMIT	100-400%	100-500%
ACCELERATION TIME	1-30 seconds	1-90 seconds
DECELERATION TIME	1-30 seconds	1-90 seconds
MAX. START TIME	1-30 seconds	1-250 seconds
PHASE LOSS Y/N	Yes[2]	Yes/No[2]
MAX SLOW SP TIME	1-30 seconds	1-250 seconds
O/C or WRONG CON protection in Inside Delta mode.	Protection active in normal set[3]	Protection active in high set[3]
OVERLOAD TRIP protection.	OVERLOAD TRIP will be active after *Run* LED is Lit. (Motor is at full voltage)[4]	OVERLOAD TRIP will be active after MAX. START TIME has elapsed.[4]

3.7.2 Software programming

This page and next page show the general map for programming RVS-DN that we treat with it in this course.




MODE
PAGE 5
EN. SAVE & SL. SPD PARAMETERS
SELECT
MODE
PAGE 6
FAULT PARAMETERS
SELECT
MODE
PAGE 7
I/0 PROGRAMING PARAMETERS
SELECT
MOD E
PAGE 8
COMM. PARAMETERS
SELECT
MODE
PAGE 9
STATISTICAL DATA .****.
SELECT
PRESS VALUE
KEYS TO CHANGE PARAMETER


SAVING ADJUST 0(MIN)
SLOW SPEED TORQ 8
MAX SLOW SP TIME 30 SEC.
STORE ENABLE EN. SAVE & SL. SPD
Back to Top
PHASE SEQ Y/N NO
NSULATION ALARM OFF
INSULATION TRIP OFF
AUTO RESET NO
THERMISTOR TYPE PTC
THERMISTOR TRIP OFF
UNDER CUR. RESET OFF
STORE ENABLE FAULT PARAMETERS
Back to Top
PROG. INPUT # 7 ENERGY SAVER
PROG. INPUT # 8 DUAL ADJUSTENT
FAULT RELAY TYPE FAULT
IMM/ S.PAIN RELAY IMMEDITE
RELAY ON DELAY 0 SEC.
RELAY OFF DEL 0 SEC.
ANALOG OUTPUT NORMAL
STORE ENABLE I/O PROG. PARAM.
Back to Top
DRIVE NUMBER 0
BAUD RATE 9600
PARITY CHECK EVEN
SERIAL LINK NO. 248 (OFF)
STORE ENABLE COMM. PARAMETERS
Back to Top
LAST STRT PERIOD NO DATA
LAST START MAXI NO DATA
TOTAL RUN TIME 0 HOURS
TOTAL # OF START 0
LAST TRIP NO DATA
TRIP CURRENT 0% OF FLA
TOTAL # OF TRIPS 0
PREVIOUS TRIP 1... 9 NO DATA
Back to Top
MO DE + STORE ENABLE DEFAULT PARAMET.
MODE + STORE
SAVE DEFAULT PARAMETERS & BACK TO PARAMETERS DISPLAY PAGE
% OF MOTOR FLA
SE LE CT RESET STATISTICS
RESET + STORE
SAVE STATISTICAL DATA & BACK TO PAGE 9
STATISICAL DATA .****.
SELECT PROGRAM VERSION RVS DN – 300400
SELECT
VOLTAGE ADJUST. x Volt
CURRENT ADJUST. x% OF RVS FLC
BACK TO:
STORE ENABLE DEFAULT PARAMET.
TO EXIT DEFAULT PARAMETERS MODE PRESS MODE +

Describe of some parameter treat with it in class

For information about programming soft starter devise back to RVS_DN instruction manual.

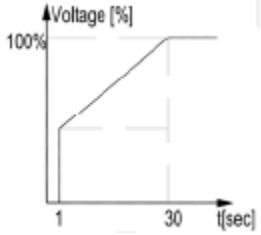
STARTER FLC
DN's FLC (Full Load Current)

MOTOR FLA
Sets motor's FLA (Full load Ampere).

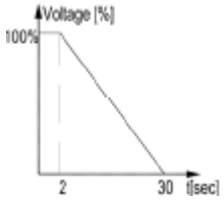
OVERLOAD TRIP
Is operational when running (the RUN LED is lit), except if using the EXPANDED SETTING as described in section ,The O/L circuitry incorporates a thermal memory register that calculates heating minus dissipation of the motor. The RVS-DN trips when the register fills up. The thermal register resets itself 15 minutes after the motor stops.

STORE ENABLE
To store selected parameters scroll through all parameters until you reach STORE ENABLE MAIN PARAMETERS, then press the Store key. After you store a parameter successfully the DATA SAVED OK message will display. If RVS-DN fails to store the parameter the LCD Will display the STORAGE ERROR message.

ACC. TIME
Determines the motor's voltage ramp-up time, from initial to full voltage. It is recommended to set ACCELERATION TIME to the minimum acceptable value (approx. 5 sec).



DEC. TIME
Used for controlled deceleration of high friction loads. Determines the motor's voltage ramp down time.



References:

http://www.sirscottsboro.com/controls/ppt/fna_ss.ppt

http://en.wikipedia.org/wiki/Motor_soft_starter

RVS_DN instruction manual.

Lecture note.

CH (4) Pump Control

By :
Mustafa Hassan Saqer.
12002 – 0292 .

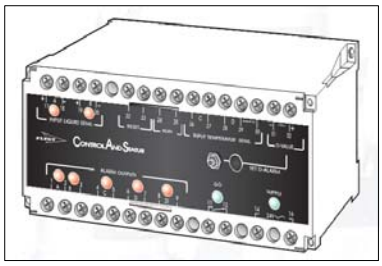
Instructor :
Prof. Muhammed Abdelati

CH (4) Pump Control

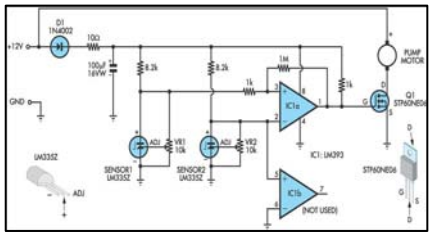
[4.1] Temperature Sensors .

[4.2] Overload Monitoring relay (EMT6) .

[4.3] Pump Control and status modules (Flyget CAS) .



[4.4] Control circuit of a water pump board .



[4.1] Temperature Sensors :

Temperature sensor: is a device that measure the temperature and return a value that reflect the actual temperature of the place that contain the sensor .

There are many types of temperature sensors, there are difference between the types of temperature sensors depends on the structure of it , the sensitivity of its response and the range of suitable temperature. These sensors translate the temperature into a reference voltage, resistance or current.
We can classify the temperature sensors in two groups :

- **Contact Temperature Sensors:**

Contact temperature sensors measure their own temperature (fig 4.1).
There are industrial and medical contact sensors .

The main types of Industrial Contact Temperature Sensors :

1) Thermocouple .
2) Resistance – RTDs .
3) Thermistors .
4) Semiconductor ICs & Diode .
5) Filled Systems .

The medical contact sensors are :

1) Labels & Paint .
2) Glass Thermometers .

Figure (4.1): contact sensors

- **Noncontact Temperature Sensors:**

measure the thermal radiant power of the Infrared or Optical radiation that they receive from a known or calculated area on its surface (fig 4.2).

The types of NonContact Temperature Sensors :

1) IR Thermometers : measure temperature from the amount of thermal electromagnetic radiation received from a spot on the object of measurement.
2) Thermal Imaging : is a type of infrared imaging science, thermographic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 0.9–14 μm) and produce images of that radiation
3) Optical Pyrometry : operates by allowing the operator to compare the intensity of light radiated from a target at visible .655μm wavelength to the known brightness of an internal calibrated lamp, used in high temperature.
4) Blackbody .

Figure(4.2): Noncontact sensors

(4.1.1) Thermocouples :

Thermocouples is a junction between two different metals that produces a voltage related to a temperature difference. Any junction of dissimilar metals will produce an electric potential related to temperature, they are based on the Seebeck effect that occurs in electrical conductors when they experience a temperature gradient along their length (fig 4.3).

The thermocouples favourable characteristics include good inherent accuracy, suitability over a broad temperature range, relatively fast thermal response, ruggedness, high reliability, low cost and great versatility of application.Thermocouples are a widely used type of temperature sensor for science , industry , measurement and control.

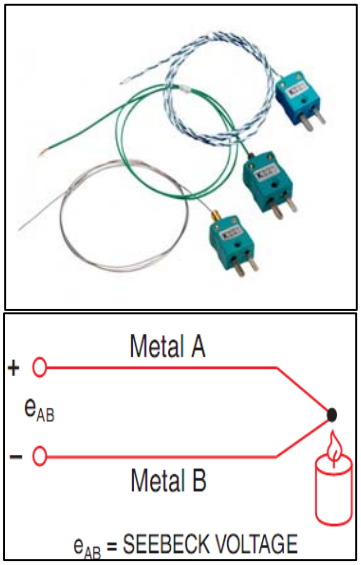


Figure (4.3): thermocouples

The types of Thermocouples sensors: (K, E, J, N, B, R, S, T, C, M)

- **K**

Type K (chromel–alumel) is the most common general purpose thermocouple with a sensitivity of approximately 41 µV/°C, chromel positive relative to alumel.
It is inexpensive, and a wide variety of probes are available in its −200 °C to +1350 °C range. Type K was specified at a time when metallurgy was less advanced than it is today, and consequently characteristics vary considerably between samples.

- **J**

Type J (iron–constantan) has a more restricted range than type K (−40 to +750 °C), but higher sensitivity of about 55 µV/°C.[2] The Curie point of the iron (770 °C) causes an abrupt change in the characteristic, which determines the upper temperature limit.

- **S**

Type S thermocouples are constructed using one wire of 90% Platinum and 10% Rhodium (the positive or "+" wire) and a second wire of 100% platinum (the negative or "-" wire), type S thermocouples are used up to 1600 °C. In particular, used as the standard of calibration for the melting point of gold (1064.43 °C).

(4.1.2) Resistive Temperature Devices (RTD) :

RTDs (resistive thermal devices) are temperature sensors that exploit the predictable change in electrical resistance of some materials with changing temperature(fig 4.4). As they are almost invariably made of platinum or pure metal, they are often called platinum resistance thermometers (PRTs). They are slowly replacing the use of thermocouples in many industrial applications below 600 °C, due to higher accuracy and repeatability .

Figure (4.4): RTDs Sensors

resistance thermometers use electrical resistance and require a power source to operate. The resistance ideally varies linearly with temperature, they are High accuracy, Low drift, Wide operating range, Suitability for precision applications , are rarely used above 600 °C .platinum RTDs are less sensitive to small temperature changes and have a slower response time.

RTD Output Equation :

$$R(t) = R(0) \times \left[1 + At + Bt^2\right]$$

Where:
t = temperature (to ITS-90) °C .
R(t) = resistance at temperature t .
R(0) = resistance at 0°C .
A = 3.9083 * 10^-3(°C), and B = -5.775 * 10^-7(°C).

Some types of platinum resistance thermometers:

- **PT-100**

PT-100 has a resistance of 100 ohms at 0 °C and 138.4 ohms at 100 °C, made from Platinum, excellent accuracy over a wide temperature range (from -200 to 400 °C). it is not necessary to use special cables to connect to the sensor. They are wire wound and thin-film.

- **PT-1000**

PT-1000 sensors that have a resistance of 1000 ohms at 0 °C, 1°C 1003.85 ohms with 10°C 1038.5 ohms and so on. The temperature coefficient amounts to depending upon platinum material +3.85 Ohm/°C.

- **Ni**

Nickel-temperature sensors (Ni-RTDs) , Thin-film, Nickel Resistance Temperature Detectors(fig4.5) are small, low-cost, brief response time, small dimensions, excellent long-term stability, simple linearization, low self-heating rate, resistant against vibration and temperature shocks, simple interchangeability.
Standards (DIN 43760, TK 5000 or other),
Temperature range (-60 to 250°C),
Typical base values 100, 500, 1000 Ω.

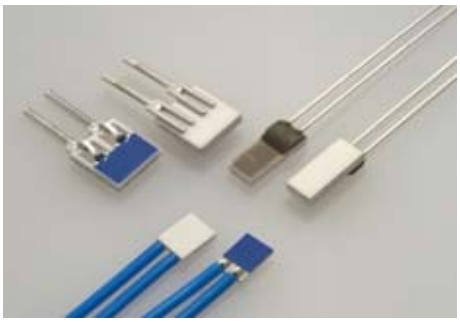


Figure 4.5 Nickel Sensors

(4.1.3) Thermistors :

A thermistor is an electronic component that exhibits a large change in resistance with a change in its body temperature. The word "thermistor" is actually a contraction of the words "Thermal, Resistor" The thermistors are ceramic or polymer semiconductors and have either large positive temperature coefficient of resistance (PTC devices) or large negative temperature coefficient of resistance (NTC devices). Both types of thermistors (PTC and NTC) have definite features and advantages which make them ideal for certain sensor applications.

Thermistors differ from resistance temperature detectors (RTD) in that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range [-40°C to 260°C].

Thermistors Equation : $$\Delta R = K \cdot \Delta T$$

Where :

ΔR = change in resistance
ΔT = change in temperature
k = first-order temperature coefficient of resistance

There are two types of Thermistors :

- **NTC**

NTC (Negative temperature coefficient) thermistors are composed of metal oxides(fig4.6). The most commonly used oxides are those of manganese, nickel, iron, copper and titanium. By varying the types of oxides used, a wide range of resistivities and temperature coefficient characteristics can be obtained.Operating temperature range: -80 ~ +125 C.

Figure (4.6)

NTC Thermistor has many Features: High measurement accuracy, Fast response, small dimension, Can operate in long time stability.
Nominal resistance at 25C can be from 2kΩ -150kΩ.

Properties and Applications of NTC :

I. Thermal Properties : power is dissipated as heat and the body temperature of the thermistor will rise above the ambient temperature of its environment.
II. Current-Time Characteristic : The rate of current change will be initially low due to the high resistance of the thermistor, can be used as inrush-current limiting devices in power supply circuits.
III. Resistance-Temperature Characteristic: There are many applications based upon the resistance-temperature characteristic and they can be grouped into the general categories of resistance thermometry,

There are many applications of NTC sensor , Such as :

1) General Industrial Applications (Industrial process controls, Fiber processing & manufacturing, Copy machines…)
2) Consumer / Household Appliances (Thermostats, Fire detection..)
3) Instrumentation Applications (Motor winding compensation, Infrared sensing ..)
4) Automotive and Transportation Applications (Emission controls, Aircraft temperatures..)

- **PTC**

PTC (Positive Temperature Coefficent) thermistors act as thermal protection for electrical machines, and well known particularly as motor-protectors. They are available with or without insulating sleeve and have flexible connecting leads.
PTC thermistors have a non-linear resistance/temperature response, PTC thermistors exhibit very high sensitivity over a narrow temperature band, the relationship of resistance and at a specified temperature the resistance changes rapidly to a very high value.

Types of PTCs are [DIN, (Single YD1, YG1 ,YGM1), (Triple YD3 YG3), MiniYGM3), Threaded housing EF1] The PTC's resistance values for motor protection are Specified DIN 44081/44082(fig4.7 , 4.8).

PTC Thermistor Features:

1. rapid response protection for electrical machines.
2. compact size for easy assembly into windings .
3. silvered copper leads
4. Excellent long term stability.
5. Wide operating temperature range .
6. up to 6 PTC's can be connected .

	single	trible	
Max. operating voltage	30	30	V
Rated response temperature ϑ_{NAT}	see ordering information		°C
Tolerance of ϑ_{NAT}	± 5	± 5	K
Reproducibility of ϑ_{NAT}	± 0.5	± 0.5	K
Resistance R_{25}	≤ 100	≤ 300	Ω
Resistance at a temperature of ϑ_{NAT} -5K	≤ 550	≤ 1650	Ω
Resistance at a temperature of ϑ_{NAT} +5K	≥ 1330	≥ 3990	Ω
Resistance at a temperature of ϑ_{NAT} +15K	≥ 4	≥ 12	kΩ
Thermal response time t_a	≤ 5	≤ 5	s
Insulation test voltage U_{is}	AC 2.5	AC 2.5	kV
Max. operating temperature	200	200	°C
Max. storage temperature	160	160	°C
Min. storage temperature	-25	-25	°C
Weight	2	3.5	g

Figure 4.7 Technical Data PTC acc. to DIN 44081/082

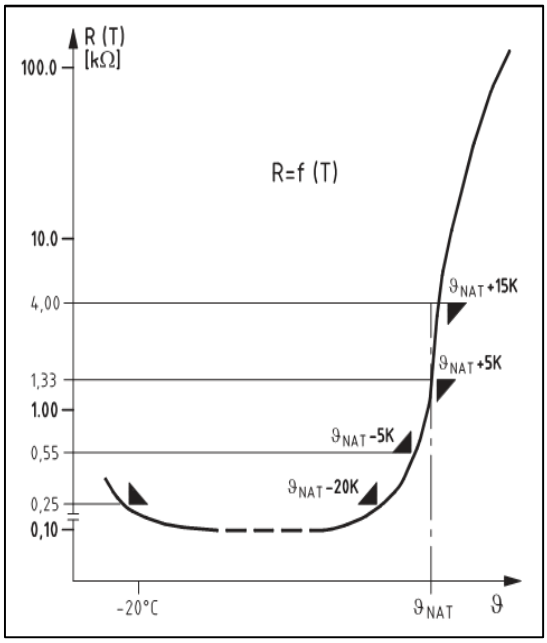


Figure 4.8 PTC characteristic curveacc. to DIN 44081/082

(4.1.4) Semiconductor Temperature Sensors :

Semiconductor temperature sensors are produced in the form of ICs (fig4.9). Their design results from the fact that semiconductor diodes have temperature-sensitive voltage vs. current characteristics. When two identical transistors are operated at a constant ratio of collector current densities, the difference in base-emitter voltages is directly proportional to the absolute temperature.

Temperature sensing ICs are available either in analog form, which output a voltage or current which is proportional to the temperature, or digital, which communicate temperature over a digital communication line, such as one-wire PWM, two-wire I2C, or a multiple wire SPI connection.

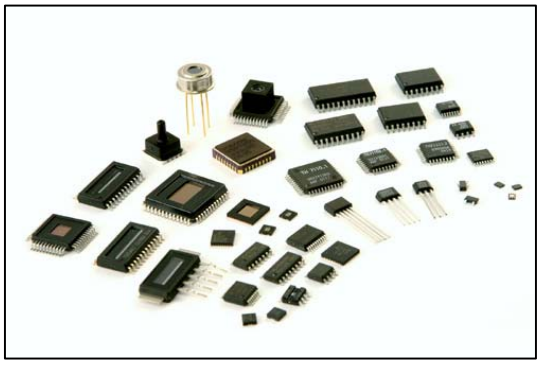


Figure 4.9 ICs Temperature

- **Analog Voltage-Output sensors**

1. LM135, LM235, LM335 Kelvin Sensors: with a nominal coefficient of 10mV/K. The nominal output voltage is therefore 2.73V at 0°C, and 3.73V at100°C.
2. LM35, LM45 Celsius Sensors: three-terminal devices and the nominal output voltage is 250mV at 25°C and 1.000V at 100°C, more accurate.
3. LM50 “Single Supply” Celsius Sensor: called a “Single Supply” Celsius Sensor because, unlike the LM35 and LM45, it can measure negative temperatures without taking its output pin below its ground pin.
4. LM34 Fahrenheit Sensor : The LM34 is similar to the LM35, but its output voltage is proportional to °F (10mV/°F).
5. LM60 2.7V Single Supply Celsius Sensor: The LM60 is similar to the LM50, but is intended for use in applications with supply voltages as low as 2.7V.

- **Current-Output Analog Sensors**

1. LM134, LM234, and LM334 Current-Output Temperature Sensors: is also a current-output temperature sensor with an output current proportional to absolute temperature. Typical sensitivities are in the 1µA/°C to 3µA/°C range, with 1µA/°C being a good nominal value.
2. LM56 Low-Power Thermostat: two comparators with preset hysteresis. It will operate from power supply voltages between 2.7V and 10V, and draws amaximum of 200µA from the power supply.

- **Digital Output Sensors**

LM75 Digital Temperature Sensor and Thermal Watchdog With Two-Wire Interface,
It contains a temperature sensor, a delta-sigma analog-to-digital converter (ADC), a two-wire digital interface, and registers for controlling the IC’s operation.

Table1: Comparison of temperature sensor types

Characteristic	Platinum RTD	Thermistor	Thermocouple	Temperature IC
Active Material	Platinum Wire	Metal Oxide Ceramic	Two Dissimilar Metals	Silicon Transistors
Changing Parameter	Resistance	Resistance	Voltage	Voltage or Current
Temperature Range	-200°C to 500°C	-40°C to 260°C	-270°C to 1750°C	-55°C to 150°C
Sensitivity	2 mv/°C	40 mV/°C	0.05 mV/°C	1 mv/°C or ~1 uA/°C
Linearity	Excellent	Logarithmic Poor	Moderate	Excellent
Response Time	2-5 s	1-2 s	2-5 s	2-4 s
Stability	Excellent	Moderate	Poor	Excellent
Base Value	100 Ω to 2 kΩ	1 kΩ to 1 MΩ	< 10 mV	Various
Noise Susceptibility	Low	Low	High	High
Special Requirements	Lead Compensation	Linearization	Reference Junction	None
Device Cost	$60 - $215	$10 - $350	$20 - $235	$5 - $50
Relative System Cost	Moderate	Low to Moderate	Moderate	Low

[4.2] Overload Monitoring relay (EMT6) :

Overload Relay EMT6 Overload monitoring system for machines protection , motors that operating in the EEx e area (potentially explosive atmospheres), fig(4.) .

(4.2.1) EMT6 Description

To protect the machinery from overload, direct temperature monitoring systems can be used in addition to current-dependent protective devices(fig4.10).
The EMT6 overload relays monitor the thermistor sensors used for monitoring temperature and switch off the power relay in the event of overheat in the machinery.

It used in many applications and devices, like motors, heating circulation fans, in the windings of various sizes of transformers, for generator protection as well as for monitoring gaseous or liquid coolants, and temperature monitoring of non-electrical mechanical equipment…etc.

Figure 4.10 :Overload protection relays EMT6, EMT6-DB and EMT6-DBK

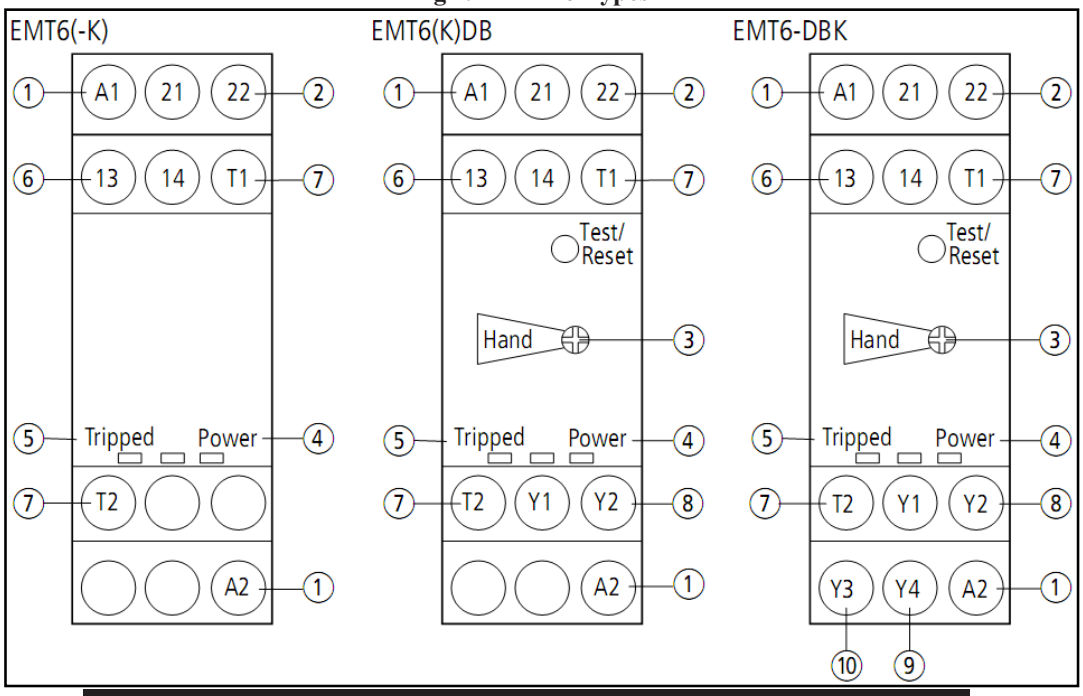
(4.2.2) Device variants

The EMT6 thermistor overload protection relay is available in seven variants:

- EMT6 and EMT6(230V)
- EMT6-K
- EMT6-DB and EMT6-DB(230V)
- EMT6-KDB
- EMT6-DBK

(4.2.3) Structure of EMT6

Fig 4.11 EMT6 Types



①	A1-A2	Rated control voltage supply
②	21-22	Auxiliary normally closed contact
③		Manual/automatic reset
④		Mains LED (green)
⑤		Tripped LED (red)
⑥	13-14	Auxiliary normally open contact
⑦	T1-T2	Thermistor
⑧	Y1-Y2	Remote reset
⑨	Y1-Y4	Zero-voltage safety disabled
⑩	Y1-Y3	Short-circuit monitoring disabled

Table 2 Ports of EMT6

(4.2.4) Thermistor protection

Thermistors as PTC resistors or positive temperature coefficient resistors. Their resistance changes sharply when a defined temperature is exceeded.

For the protection against over temperature, up to (six DIN 44081 PTC), or up to (two DIN 44082 Triple PTC with resistance of R<= 250Ω), or (nine sensors with a PTC resistance of R<= 100Ω) can be connected to the EMT6 terminals T1-T2(fig4.12).

The EMT6 switches off at R = 3600 Ω ±10% and switches on again at R = 1600 Ω ±10%.

The NO & NC contacts change over in the event of a shutdown caused by a signal at the thermistor

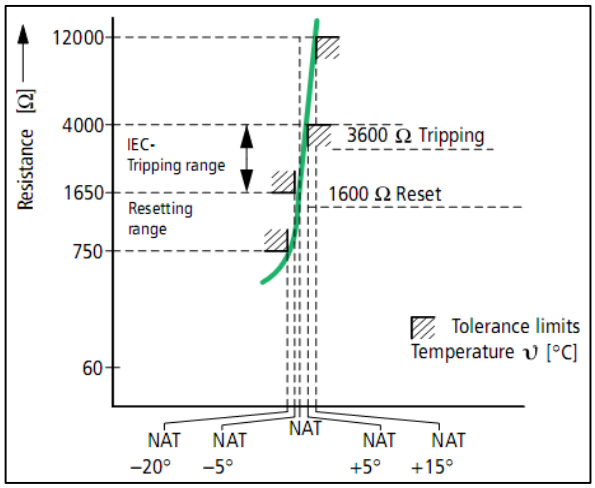


Figure 4.12 Characteristic curve for monitoring temperature with a thermistor

(4.2.5) Properties of EMT6

- **Reset after triggering**

1) The error message of the standard EMT6 is automatically reset after the equipment (motor winding) temperature has dropped to a sufficiently low level(fig4.13,14,15).
2) The operating mode of the EMT6-DB, EMT6-KDB and EMT6-DBK variants can be set to “Automatic” or “Manual reset” using the selector switch.
3) In automatic mode, the devices are reset automatically.
4) In manual mode, they are reset after the motor has cooled down.
5) The EMT6-DB, EMT6-KDB and EMT6-DBK have an additional option of connecting a button as a remote reset for manual mode.

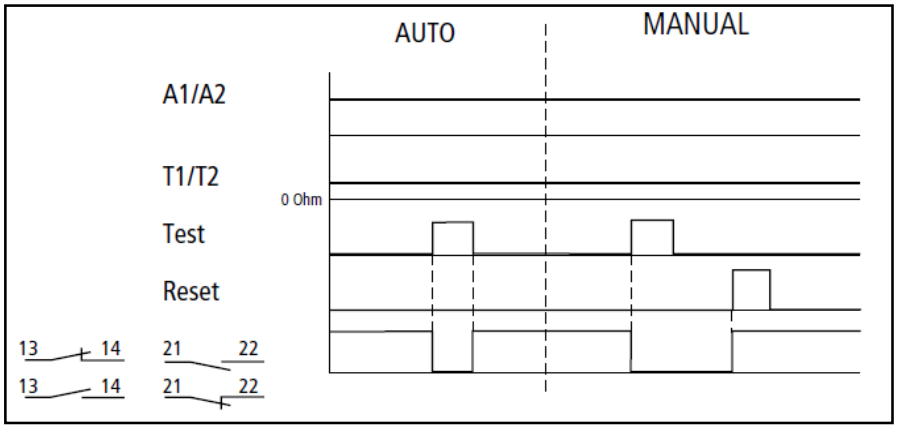


Figure 4.11 Function diagram for Manual reset

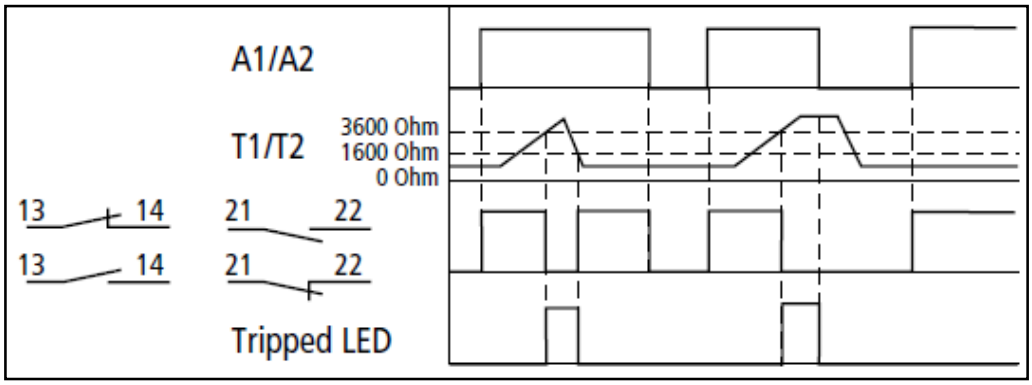


Figure 4.12 Function diagram for automatic reset

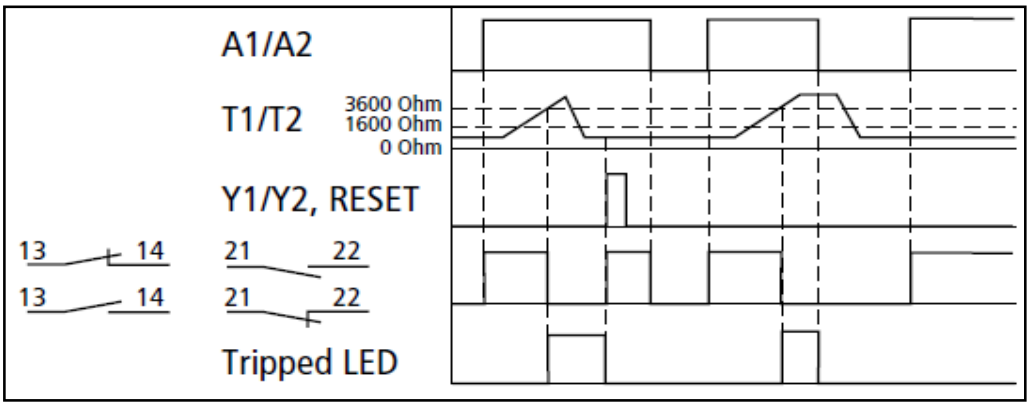


Figure 4.15 Functional diagram of the manual reset

- **Short-circuit monitoring of the thermistor circuit**

1) The sensor circuits of the EMT6-K, EMT6-KDB and EMT6-DBK have additional short circuit monitoring in the sensor circuit which immediately switches off the relay when the resistive load of the sensor circuit drops below a minimum value(fig4.16,17).
2) The short-circuit monitoring of the EMT6-DBK can be disabled by means of a wire jumper between terminals Y1-Y3.

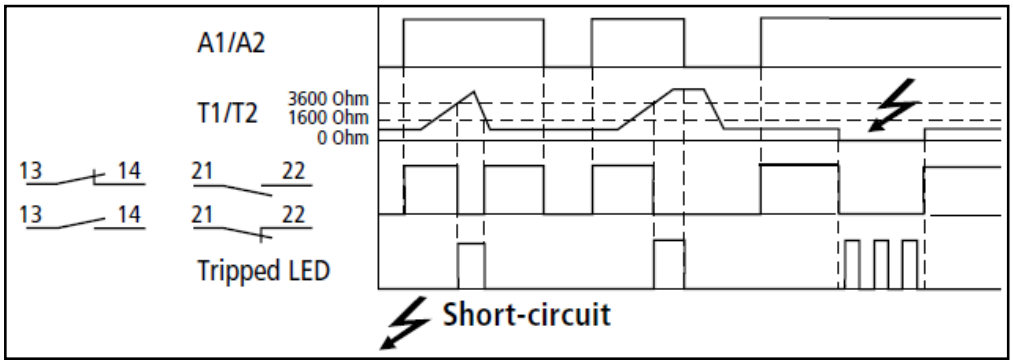


Figure 4.16 Function diagram of automatic reset with short-circuit

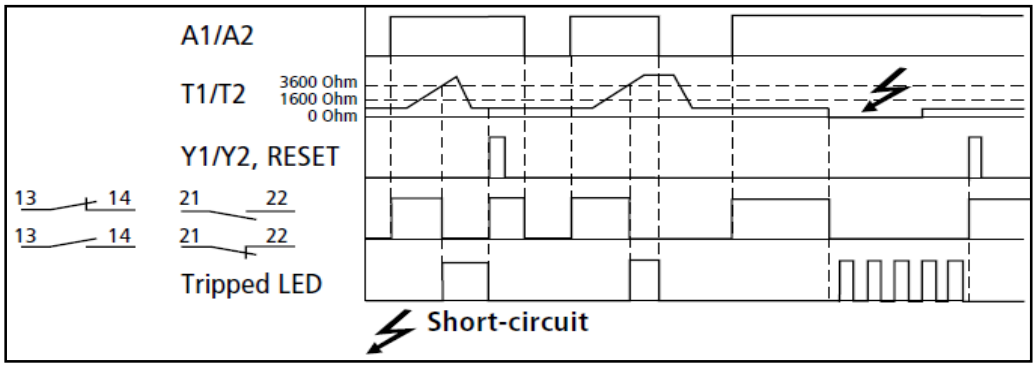


Figure 4.17 Functional diagram of the manual reset with short circuit monitoring.

- **Zero-voltage protection**

1) Zero-voltage protection means that the error message is retained even after loss of the supply voltage (fig4.18).
2) Zero-voltage protection can be enabled or disabled on the EMT6-DBK. If the equipment has not yet cooled down sufficiently after power is returned, the relays with disabled zero-voltage protection will also be tripped again.
3) The message of devices with disabled zero-voltage protection will be lost only if power is returned after the equipment has cooled down during an extended period of power loss.

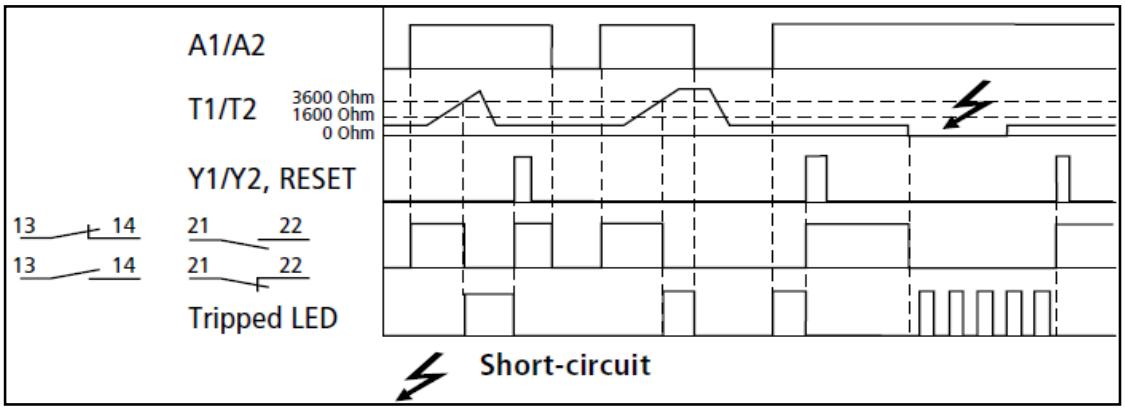


Figure 4.18 Functional diagram of zero-voltage protected operation and short-circuit protection in the sensor circuit

(4.2.6) Features and differences of EMT6 Types

Table 3 features of EMT6

	EMT6 EMT6(230V)	EMT6 K	EMT6-DB EMT6-DB(230V)	EMT6 KDB	EMT6 DBK
Function					
Automatic Reset	✓	✓	✓	✓	✓
Manual Reset	×	×	✓	✓	✓
Detection of short-circuit in the sensor circuit	×	✓	×	✓	✓
Zero-voltage safety	×	×	×	×	✓
Operator control					
Test button	×	×	✓	✓	✓
Reset button	×	×	✓	✓	✓
Remote reset	×	×	✓	✓	✓
Selector switch MANUAL/AUTO reset	×	×	✓	✓	✓
Display					
Operating voltage	✓	✓	✓	✓	✓
Tripping	✓	✓	✓	✓	✓
Fault short-circuit	×	✓	×	✓	✓
Voltage					
Multiple voltage of 24 V to 240 V h/H	✓	✓	✓	✓	✓
Single voltage 230 V h	✓	×	✓	×	×

[4.3] Pump Control and status modules (Flyget CAS).

CAS (control and status) designed for use in pumps/turbines to protect the pumps or turbines from high temperature, leakage liquid and oil pressure(fig4.19).

(4.3.1) Structure Of CAS :

It consist of :

- 32 ports and they are :

1) four channels (channel A , B , C , D)
2) Alarm outputs .
3) supply input .
4) Interlock (Go) output to pump/turbine.
5) Reset .
6) Run .

- 9 pilots .

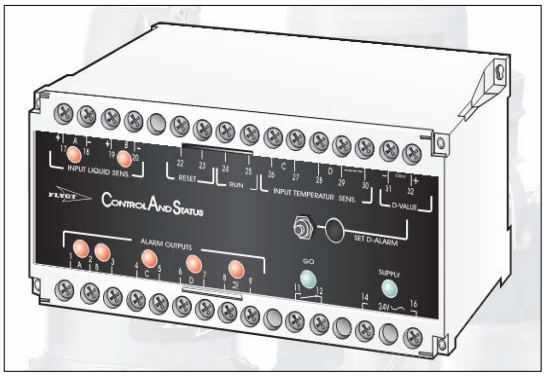


Figure (4.13): Control and status CAS

(4.3.2) Electrical Connection

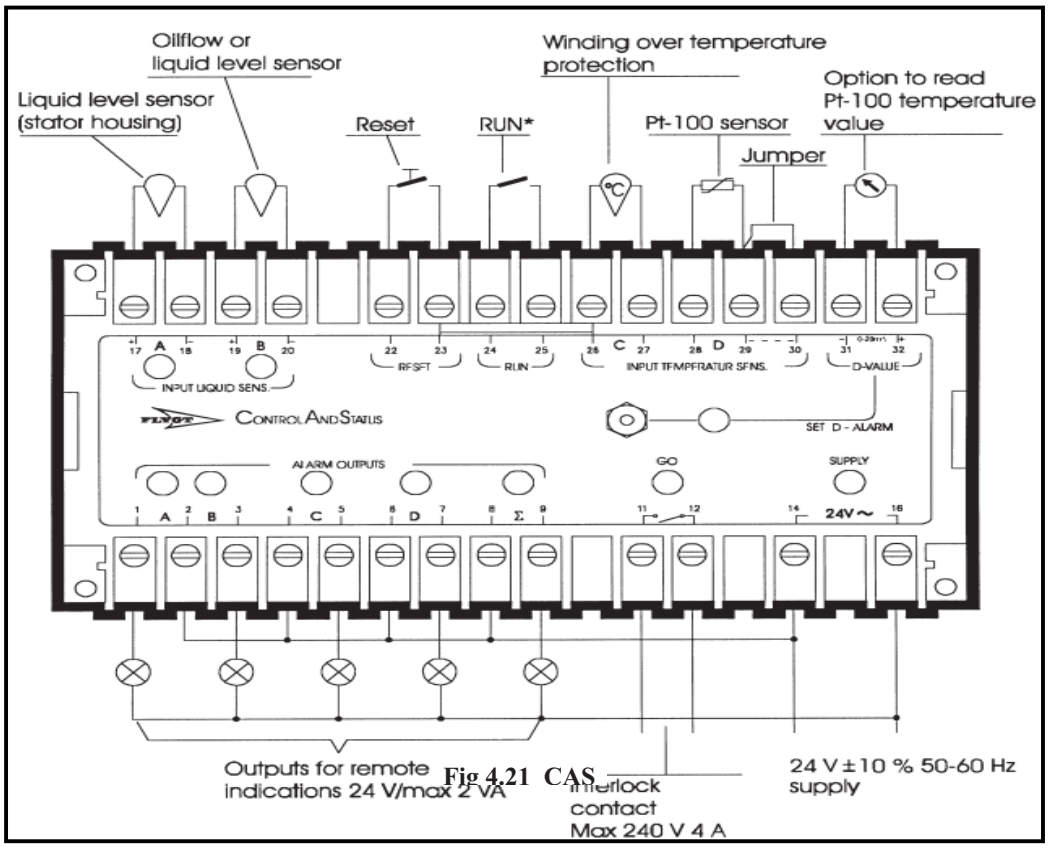
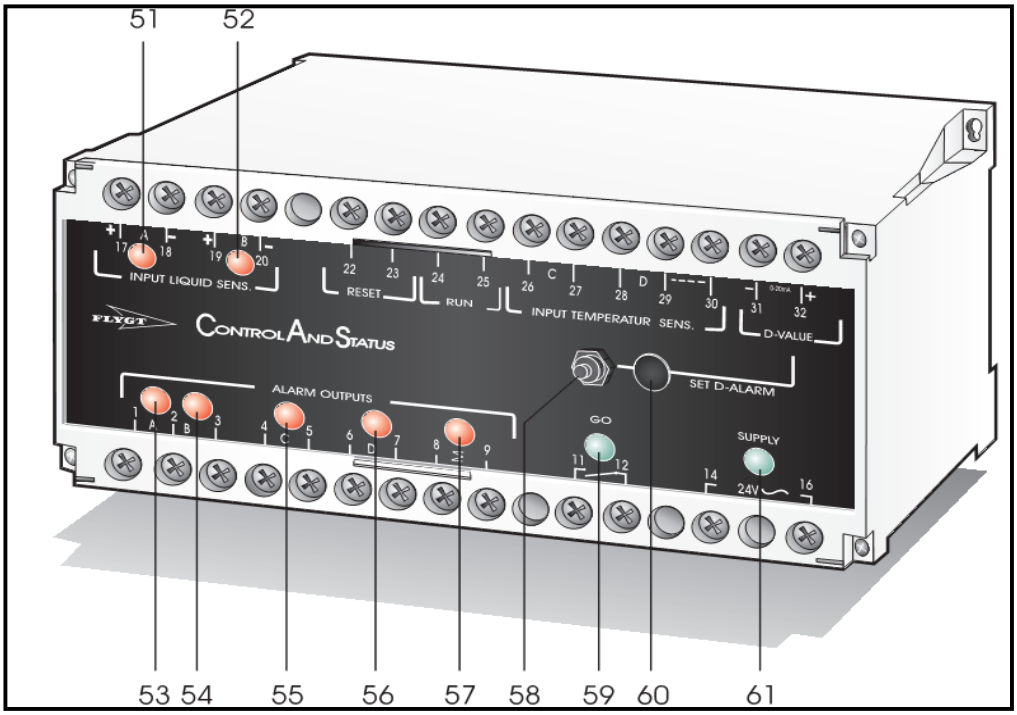


Fig 4.21 CAS

Fig 4.20 Electrical connection of CAS



Fig(4.21) CAS Description

Table 4 CAS ports Description

Port 1,2	channel A alarm .
Port 2,3	channel B alarm .
Port 4,5	channel A alarm .
Port 6,7	channel C alarm .
Port 8,9	sigma alarm .
Port 11,12	Interlock (Go) Port .
Port 14,16	Supply Port .
Port 17,18	channel A Sensor Input .
Port 19,20	channel B Sensor Input .
Port 22,23	Reset Port .
Port 24,25	Run Port .
Port 26,27	channel C Sensor Input .
Port 28,29	channel D Sensor Input .
Port 31,32	D-Analogue Port

Notes:

- the jumper of port 29-30 .
- the run port should connected with the machine status (On-Off) .
- the run port is normally connected with port B , why?
- Power Supply 24V, 50-60 Hz Frequency .
- Reset Port is normally open but the interlock Port is normally closed .

(4.3.3) How To Use CAS :

Table 5

Channel	Measurement
A	Liquid Level , Water in Oil
B	Oil Pressure , Liquid Level
C	Temperature, PTC Thermistors
D	Temperature, Pt-100 Sensor

- **Channel A (liquid level):**

This channel is used, for example, for monitoring of possible liquid leakage into the stator casing. A sensoris incorporated in the lower part of the stator casing.
The sensor changes resistance from about 1.5 kΩ to about 330 Ω if liquid enters.
Another sensor that can be connected to this channel is the water in oil sensor, called CLS (capacitive leakage sensor). The CLS-30 monitors the content of water in the oil housing or the gear box and alarms at a percentage > 35.

Input indication
The pilot lamp 51 is lit to indicate interruption or short-circuit.

Alarm
After alarm for about 5 seconds, the alarm function A is activated, the red pilot lamp 53 is lit, the Σ-alarm function is activated (the pilot lamp is lit) and the interlock (11 – 12) drops, whereby the pump/turbine is disconnected and the pilot lamp 59 will go out.

Reset
Resetting can only be done manually, by pushing the reset button connected to the entrance (22, 23).

- **Channel B (oil pressure or liquid level):**

This channel with RUN connected to a normally open contact is to be used to monitor the oil pressure in machines equipped with a gear unit. On machines without a gear unit, the channel can be used in the same manner as channel A, provided that RUN is not connected.

Input indication
The pilot lamp 52 is lit to indicate interruption or short circuit. If the channel is not used (machines without a gear unit) the pilot lamp will always light.

Alarm
After an alarm from the sensor for about 5 seconds, the alarm function B is activated, the pilot lamp 54 is lit, the Σ-alarm function is activated, the pilot lamp 5 is lit and the interlock (terminals 11 and 12) drops, whereby the pump/turbine is disconnected and the pilot lamp 59 will go out.

Reset
Resetting can only be done manually.

- **Channel C (temperature monitoring):**

This channel is intended to monitor the stator's temperature with thermal switches or up to 3 PTC thermistors. The thermal switches are normally closed but they open at 140°C ± 5°C (284°F).

Alarm
When the resistance exceeds 3 kΩ, the alarm function C is activated, the pilot lamp 55 is lit, the Σ-alarm function is activated, the pilot 57 is lit and the interlock (terminals 11 and 12) drops, whereby the pump/turbine is disconnected and the pilot lamp 59 is put out.

Reset
Resetting can only be done manually and only when the resistance has fallen to about 900 Ω, i.e. the stator has cooled down.

- **Channel D (Pt 100 sensor):**

This channel is used for monitoring and analog indication of the temperature of the main (lower) bearing. The channel can only be connected to a temperature sensor of type Pt-100 (DIN 437 60). The alarm value can be set by potentiometer 60 .The unit is delivered set to an alarm value of 100°C (212°F).

Indicator instrument (extra equipment)
The channel has an output for analog reading of the bearing temperature. An indicator instrument can be connected to terminals 31 and 32. The instrument shows the Pt-100 sensor's temperature. If switch 58 is depressed, the instrument shows the set alarm value.

Alarm
When the alarm value is reached, the alarm function is activated, the pilot lamp 56 is lit and the Σ-alarm function is activated. The pilot lamp 57 is lit and the interlock (terminals 11 and 12) drops, whereby the pump/turbine is disconnected and the pilot lamp 59 will go out.

Reset
Resetting can only be done manually.

(4.3.4) Technical Data

Technical Data	
Power Supply	24 V AC ±10 % 50 – 60 Hz
Power Consumption	Max 5 VA
Dimension	(W × H x D) 150×70×112 (5.9×2.75×4.4)
Temp range	0°C – + 50°C (32°F–122°F). Max 80% RH
Channel A	12 V DC I > 20 mA
Channel B	12 V DC I > 20 mA
Channel C	R ≥ 3kΩ Manual when R < 900 Ω
Channel D	R > Rset Max. load approx. 250 Ω 0 – 20 mA range 50°C – 150°C (122°F–302°F) (0,2 mA/°C ±2,5 %)
Sigma alarm	Activated by alarm from each individual channel Solid state relay 24 V AC, 100 mA
Interlock (G0)	Activated by alarm and supply failures Normally closed 240 V 4 A vid $\cos\varphi = 1$

[4.4] Control circuit of a water pump board .

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Electrical Engineering Department

CH5
Electrical Cables

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5.2.2 Example

5.1.1 Introduction:

Cables can be defined as two or more wires or ropes running side by side and bonded, twisted or braided together to form a single assembly we use it into power or control circuits.

5.1.2 Cable classified mainly according to

1-isulating material
2-conductor material.
3-screening material (if it exist).
4-dimentions of cable.

5.1.3 Cable code:

- **First 2-3 letter** : refer to conducting and isolation material for example:
- NY: cupper with PVC isolator
- N#X: cupper with XLPE isolator, given that #:refer to other letter give more information about cable
- NA: aluminum with PVC isolator
- **Other letter** : Description about cable

For example:

- **YY** : Flex works well in situations with light mechanical stress and is suited to most environments. It can be used outside when protected and in both dry and moist conditions indoors.
- **CY** : Control Cable. This Multicore Flex has a tinned copper wire braid and a PETP (Polyethylene Terephthalate) separator, which work together to protect the Control Cable from external electromagnetic influences and some mechanical stresses.
- **SY** : Flex is the toughest one of the family. If you need reliable mechanical protection, the galvanised steel wire braid on this Control Cable puts it in a league of its own.

5.1.4 Cable insulation materials :

- **Rubber** : For many years wiring cables were insulated with vulcanised natural rubber (VIR). Much cable of this type is still in service, although it is many years since it was last manufactured. Since the insulation is organic, it is subject to the normal ageing process, becoming hard and brittle. In this condition it will continue to give satisfactory service unless it is disturbed, when the rubber cracks and loses its insulating properties. It is advisable that wiring of this type which is still in service should be replaced by a more modern cable. Synthetic rubber compounds are used widely for insulation and sheathing of cables for flexible and for heavy duty applications .
- **Paper** : Dry paper is an excellent insulator but loses its insulating properties if it becomes wet. Dry paper is hygroscopic, that is, it absorbs moisture from the air. It must be sealed to ensure that there is no contact with the air. Because of this, paper insulated cables are sheathed with impervious materials, lead being the most common. PILC (paper insulated lead covered) is traditionally used for heavy power work. The paper insulation is impregnated with oil or non-draining compound to

improve its long-term performance. Cables of this kind need special jointing methods to ensure that the insulation remains sealed. This difficulty, as well as the weight of the cable, has led to the widespread use of p.v.c. and XLPE (thermosetting) insulated cables in place of paper insulated types.

- **P.V.C**. : Polyvinyl chloride (p.v.c.) is now the most usual low voltage cable insulation. It is clean to handle and is reasonably resistant to oils and other chemicals. When p.v.c. burns, it emits dense smoke and corrosive hydrogen chloride gas. The physical characteristics of the material change with temperature: when cold it becomes hard and difficult to strip, and so BS 7671 specifies that it should not be worked at temperatures below 5°C. However a special p.v.c. is available which remains flexible at temperatures down to -20°C. At high temperatures the material becomes soft so that conductors which are pressing on the insulation (eg at bends) will 'migrate' through it, sometimes moving to the edge of the insulation. Because of this property the temperature of general purpose P.V.C. must not be allowed to exceed 70°C, although versions which will operate safely at temperatures up to 85°C are also available. If p.v.c. is exposed to sunlight it may be degraded by ultra-violet radiation. If it is in contact with absorbent materials, the plasticiser may be 'leached out' making the p.v.c. hard and brittle
- **Thermosetting (XLPE)** : Gross-linked polyethylene (XLPE) is a thermosetting compound which has better electrical properties than p.v.c. and is therefore used for medium- and high-voltage applications. It has more resistance to deformation at higher temperatures than p.v.c., which it is gradually replacing. It is also replacing PILC in some applications. Thermosetting insulation may be used safely with conductor temperatures up to 90°C thus increasing the useful current rating, especially when ambient temperature is high. A LSF (low smoke and fume) type of thermosetting cable is available**.**
- **LSF** : Low smoke and fume Materials which have reduced smoke and corrosive gas emissions in fire compared with p.v.c. have been available for some years. They are normally used as sheathing compounds over XLPE or LSF insulation, and can give considerable safety advantages in situations where numbers of people may have to be evacuated in the event of fire**.**
- **Mineral :** Provided that it is kept dry, a mineral insulation such as magnesium oxide is an excellent insulator. Since it is hygroscopic (it absorbs moisture from the air) this insulation is kept sealed within a copper sheath. The resulting cable is totally fireproof and will operate at temperatures of up to 250°C. It is also entirely inorganic and thus non-ageing. These cables have small diameters compared with alternatives, great mechanical strength, are waterproof, resistant to radiation and electromagnetic pulses, are pliable and corrosion resistant. In cases where the copper sheath may corrode, the cable is used with an overall LSF covering, which reduces the temperature at which the cable may be allowed to operate. Since it is necessary to prevent the ingress of moisture, special seals are used to terminate cables. Special mineral-insulated cables with twisted cores to reduce the effect of electromagnetic interference are available

5.1.5 Cable marks (DIN VDE-JUS) :

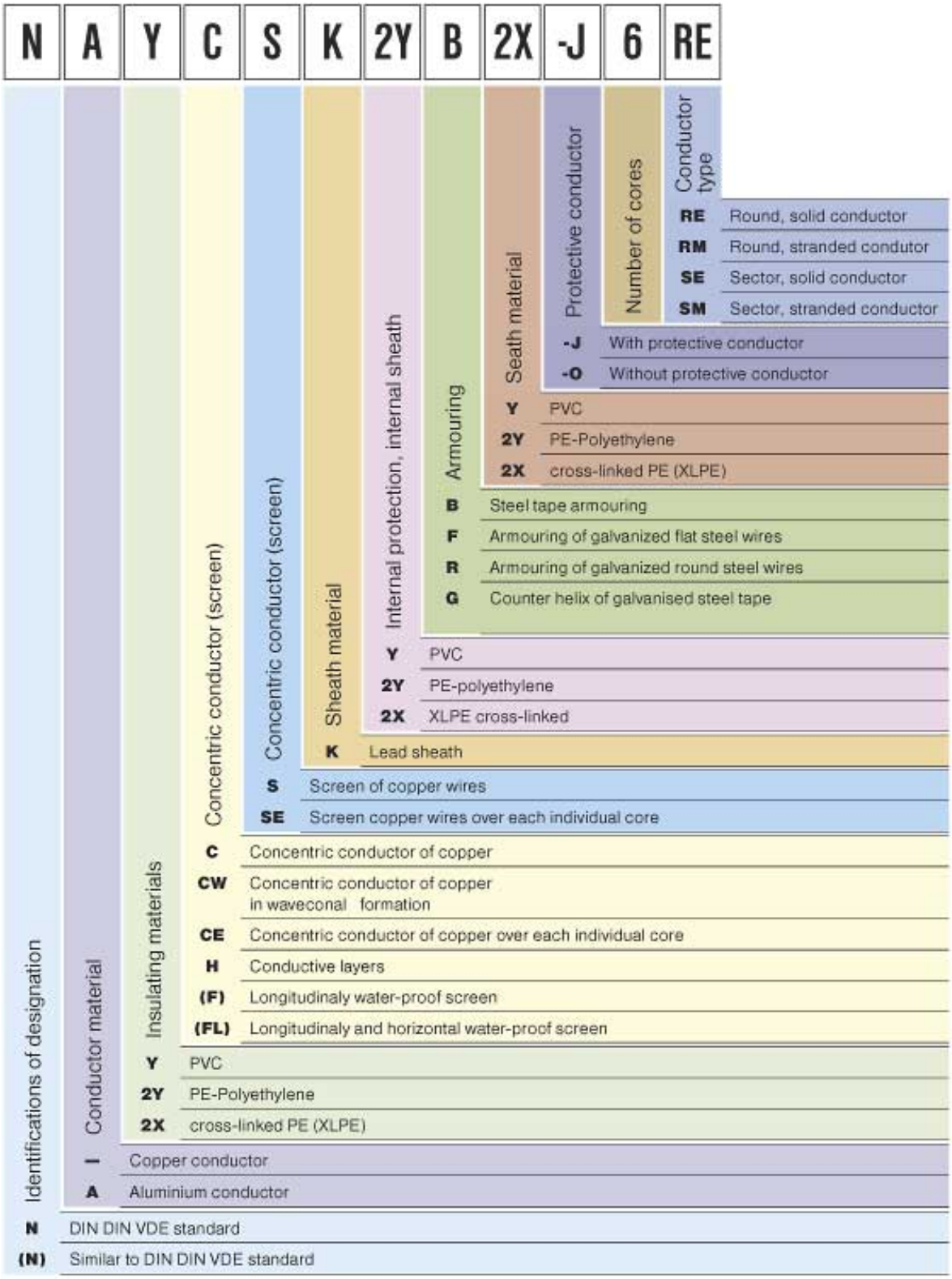
Construction of cables at rated voltage up to 1 kV

DIN VDE	JUS	Description of cordes and cables	Conductor	Insulating materials/ sheathing
H05V-U H07V-U H07V-R	**P**	PVC single core for a variety of applications mostly used for internal wiring of appliances and apparatures as well as for installation in cable ducts and in or above plaster.	**Cu**	**PVC**
H05V-K H07V-K	**P/F**	PVC single core for a variety of applications / finely stranded conductor / used for internal wiring of appliances and apparatures as well as for installation in cable ducts and in or above plaster.	**Cu**	**PVC**
H03VH-H	**P/L**	Especially suitable to be used on small appliances with low mechanical stress and for connection for light household appliances, e.g. kitchen utensils, desk lamps, office machines This cables are not allowed to be used with cooking or heating aparatures, nor for outdoor use for industrial or farmer machineries.	**Cu**	**PVC/PVC**
H03VV-F H03VV-H	**PP/L**	PVC insulated and sheathed flexible cables, especialy suitable to be used on small appliances with low mechanical stress and for conection for light household appliances, e.g. kitchen utensils, desk lamps, office machines in case that this type of cable is provided in technical datas for mentioned appliances. This cables are not allowed to be used with cooking or heating aparatures, nor for outdoor use, for industrial or farmer machineries.	**Cu**	**PVC/PVC**
H05VV-F	**PP/J**	PVC insulated and sheathed flexible cables suitable for appliances with medium mechanical stress, in households,kitchens, offices and for appliances in damp and wet surroundings. Usage for cooking and heating apparatures, when the cable does not come in direct contact with hot parts of apparatures. Suitable also for fixed instalation in furniture and partition walls. Not allowed to be used with industrial and farmer machineries.	**Cu**	**PVC/PVC**
NYIFY-O NYIFY-J	**PP/R PP/R-Y**	Flat cable, PVC insulated and sheathed used for fixed installation, layed in or beneath plaster in dry surroundings only. The cables must be covered by plaster along their entire length. The construction allows appropriate fixation of cable.	**Cu**	**PVC**
NYM-J	**PP-Y**	PVC instalation cables suitable for industrial and	**Cu**	**PVC/PVC**

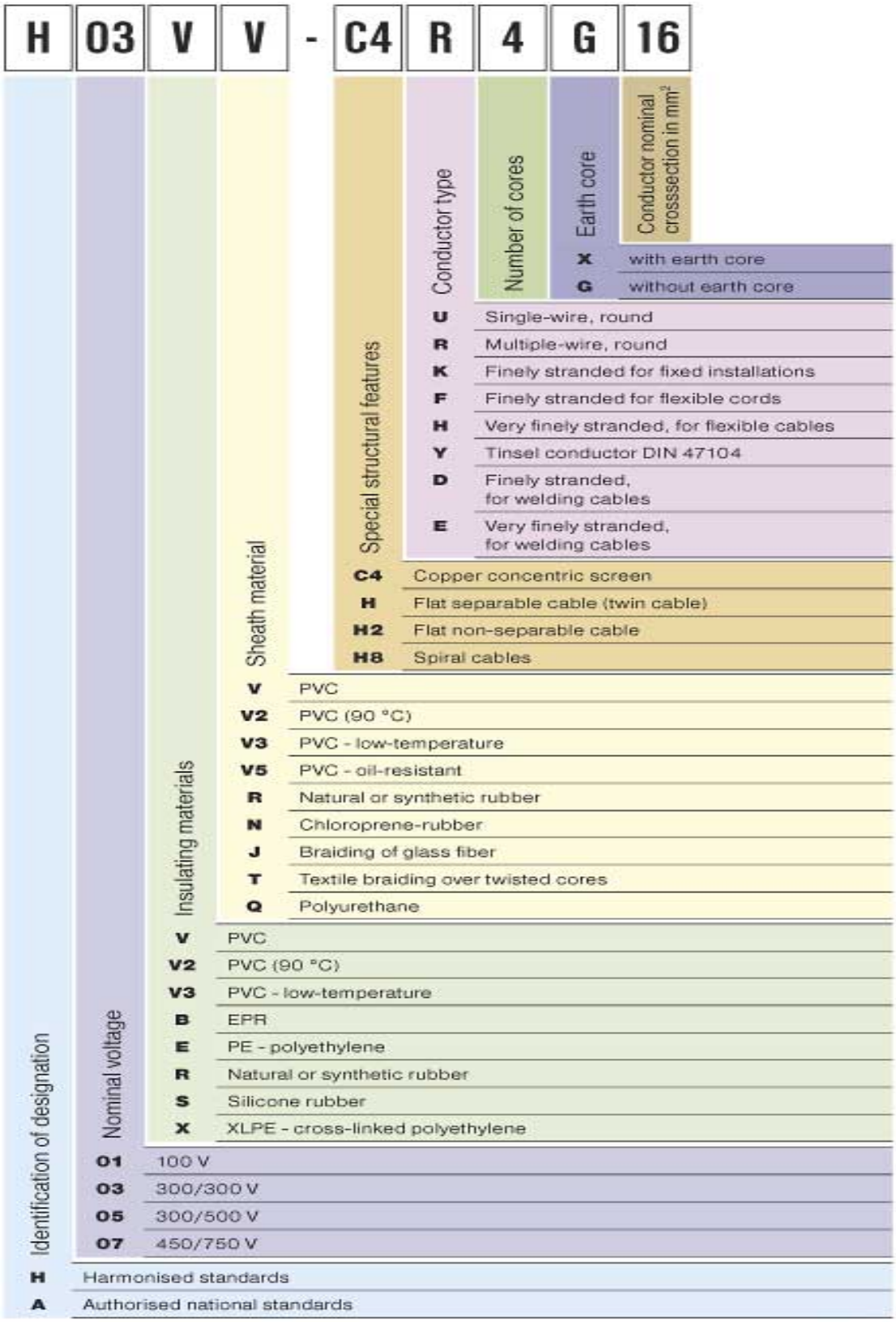
NYM-O	**PP**	wiring purposes. Installation in open, in dry, damp and wet surroundings, in or above plaster, but not in compressed concrete. Installation in open requires protection against direct sunlight.		
NYY-J NYY-O	**PP00-Y PP00**	PVC insulated and sheathed control, signal and power cables for energy supply are installed in open, underground, in water, indoors, in cable ducts, power stations, for industry and distribution boards, in subscriber networks, where mechanical damages are not to be expected.	**Cu**	**PVC/PVC**
NAYY-J NAYY-O	**PP00-AY PP00-A**	PVC insulated and sheathed control, signal and power cables are installed in open underground, in water, indoors, in cable ducts, power stations, for industry and distribution boards, in subscriber networks, where mechanical damages are not to be expected.	**Al+(Cu)**	**PVC/PVC**
N2XY-J N2XY-O	**XP00-Y XP00**	XLPE insulated and PVC sheathed control, signal and power cables for energy supply are installed in open, underground, in water, indoors, in cable ducts, power stations, for industry and distribution boards, in subscriber networks, where mechanical damages are not to be expected.	**Cu**	**PVC/XLPE**
NA2XY-J NA2XY-O	**XP00-AY XP00-A**	XLPE insulated and PVC sheathed control, signal and power cables for energy supply are installed in open, underground, in water, indoors, in cable ducts, power stations, for industry and distribution boards, in subscriber networks, where mechanical damages are not to be expected.	**Al+(Cu)**	**PVC/XLPE**
NY2Y-J NY2Y-O	**PE00-Y PE00**	PVC insulated and HDPE sheathed control, signal and power cables are installad in open, underground, in water, indoors in cable olucts, power stations, for industry and distribution boards, in subscriber networks, where mechanical domages are expected.	**Cu**	**HDPE/PVC**
NAY2Y-J NAY2Y-O	**PE00-AY PE00-A**	PVC insulated and HDPE sheathed control, signal and power cables are installad in open, underground, in water, indoors in cable olucts, power stations, for industry and distribution boards, in subscriber networks, where mechanical domages are expected.	**Al+(Cu)**	**HDPE/PVC**
NFA2X	**X00-A X00/0-A**	XLPE sheathed cable bunch is used for energy supply in subscriber network, industry, for public lighting, also as connecting cables. Instalation to pillars or other constructions by hanging.	**Al Al Mg**	**XLPE**

5.1.6 Designation codes for harmonized cables：

- Power cables according to DIN VDE 0271/0272/0273/0276



- Cables and wires according to DIN VDE 0281/0282



5.1.6 Standards cable:

- ❖ in our studying we use the ICE standards of cables . The IEC is the world's leading organization that prepares and publishes International Standards for all electrical, electronic and related technologies collectively known as electrotechnology.

Now we will show some of standards cables :

- 450/750 V - SINGLE CORE NON SHEATHED AND 300/500 V - SINGLE CORE SHEATHED COPPER CONDUCTOR PVC INSULATED UNSHEATHED or PVC SHEATHED CABLES (Cu/PVC or Cu/PVC/PVC)

Nominal Area of Conductor	maximum Conductor Resistance at 20°	Thickness of Insulation	Cu/PVC		Cu/PVC/PVC			Standard Packing Length
			Max Overall Diameter	Approx. Cable Weight	Thickness of Sheath	Max Overall Diameter	Approx. Cable Weight	
Sqmm	Ohm/Km	mm	mm	Kg/Km	mm	mm	Kg/Km	Yard/Meter
1.0†	18.1	0.6	2.7	15	0.8	4.5	31	100 Y
1.5*	12.1	0.7	3.2	21	0.8	4.9	39	100 Y
1.5	12.1	0.7	3.3	22	0.8	5.2	41	100 Y
2.5*	7.41	0.8	3.9	32	0.8	5.8	52	100 Y
2.5	7.41	0.8	4.0	34	0.8	6.0	55	100 Y
4	4.61	0.8	4.6	49	0.9	6.8	76	100 Y
6	3.08	0.8	5.2	68	0.9	7.4	98	100 Y
10	1.83	1.0	6.7	115	0.9	8.8	150	100 Y
16	1.15	1.0	7.8	170	1.0	10.5	215	100 Y
25**	0.727	1.2	9.7	265	1.1	12.5	325	1000 M
35	0.524	1.2	10.9	360	1.1	13.5	425	1000 M
50	0.387	1.4	12.8	490	-	-	-	1000 M
70	0.268	1.4	14.6	690	-	-	-	1000 M
95	0.193	1.6	17.1	950	-	-	-	500 M
120	0.153	1.6	18.8	1180	-	-	-	500 M
150	0.124	1.8	20.9	1480	-	-	-	500 M
185	0.0991	2.0	23.3	1810	-	-	-	500 M
240	0.0754	2.2	26.6	2360	-	-	-	500 M
300	0.0601	2.4	29.6	2960	-	-	-	500 M
400	0.0470	2.6	33.2	3820	-	-	-	500 M
500	0.0366	2.8	36.9	4810	-	-	-	500 M
630	0.0283	2.8	41.1	6180	-	-	-	250 M

- 600/1000 V – SINGLE CORE COPPER CONDUCTOR PVC INSULATED PVC SHEATHED CABLES (Cu/PVC/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Thickness of Outer Sheath	Approx. Overall Diameter	Approx. Cable Weight	Standard Packing Length
Sqmm	Ohm/Km	mm	mm	mm	Kg/Km	Yard/Meter
1.5*	12.1	0.8	1.4	6.4	58	100 Y
1.5	12.1	0.8	1.4	6.6	62	100 Y
2.5*	7.41	0.8	1.4	6.8	71	100 Y
2.5	7.41	0.8	1.4	7.0	75	100 Y
4	4.61	1.0	1.4	7.9	100	100 Y
6	3.08	1.0	1.4	8.5	125	100 Y
10	1.83	1.0	1.4	9.2	170	100 Y
16	1.15	1.0	1.4	10.3	235	100 Y
25	0.727	1.2	1.4	12.0	345	1000 M
35	0.524	1.2	1.4	13.1	445	1000 M
50	0.387	1.4	1.4	14.6	585	500 M
70	0.268	1.4	1.4	16.2	795	500 M
95	0.193	1.6	1.5	18.7	1090	500 M
120	0.153	1.6	1.5	20.2	1330	500 M
150	0.124	1.8	1.6	22.2	1650	500 M
185	0.0991	2.0	1.7	24.4	2020	500 M
240	0.0754	2.2	1.8	27.5	2600	500 M
300	0.0601	2.4	1.9	30.1	3230	500 M
400	0.0470	2.6	2.0	33.6	4140	500 M
500	0.0366	2.8	2.1	37.4	5200	500 M
630	0.0283	2.8	2.2	43.2	6660	250 M
800	0.0221	2.8	2.3	47.4	8340	250 M
1000	0.0176	3.0	2.5	53.6	10600	250 M

- 300/300 V - PARALLEL TWIN Copper Conductor PVC Insulated H03 VH - H as per BS 6500 – 1994 (Cu/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Overall Dimensions of Cable (Max.)	Standard Coil Length
Sq. mm	Ohm/Km	mm	mm	Yards
0.5	39.0	0.8	3.0 X 6.0	100
0.75	26.0	0.8	3.2 X 6.4	100

- 600/1000 V - SINGLE CORE Copper Conductor PVC Insulated Cables for switchgear and Control gear wiring type (Cu/PVC)

Type	Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	mean Overall Diameter (Max.)	Approx. Cable Weight	Standard Packing Length	Drum Size/Coil	Approx. Gross weight
	Sq. mm	Ohm/Km	mm	mm	kg/km	Metre		Kg
CU	1.0	18.1	0.8	3.2	18	100	Coil	1.8
	1.5	12.1	0.8	3.5	23	100	"	2.3
	2.5	7.41	0.8	3.9	32	100	"	3.2

- 600/1000 V - SINGLE CORE COPPER CONDUCTOR PVC INSULATED ALUMINUM WIRE ARMORED PVC SHEATHED CABLES (Cu/PVC/PVC/AWA/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Thickness of Extruded Bedding`	Armour Wire Diameter	Thickness of Outer Sheath	Approx. Overall Diameter	Standard Packing Length
Sqmm	Ohm/Km	mm	mm	mm	mm	mm	meter ± 10%
50*	0.387	1.4	0.8	1.6	1.5	19.6	500
70*	0.268	1.4	0.8	1.6	1.6	21.4	500
95*	0.193	1.6	0.8	1.6	1.6	23.7	500
120	0.153	1.6	1.0	1.6	1.7	25.8	500
150	0.124	1.8	1.0	1.6	1.7	27.6	500
185	0.0991	2.0	1.0	1.6	1.8	29.8	500
240	0.0754	2.2	1.0	1.6	1.9	32.9	500
300	0.0601	2.4	1.0	1.6	1.9	35.3	500
400	0.0470	2.6	1.2	2.0	2.1	40.2	500
500	0.0366	2.8	1.2	2.0	2.1	43.6	500
630	0.0283	2.8	1.2	2.0	2.2	49.4	250
800	0.0221	2.8	1.4	2.5	2.4	55.2	250
1000	0.0176	3.0	1.4	2.5	2.5	61.2	250

- 600/1000 V - Single Core Flexible Cables Copper Conductor PVC Insulated Cables for Switchgear and Control gear Wiring CK As per BS 6231 – 1990 (Cu/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance of 20°C	Thickness of Insulation	Mean Overall Diameter (Max.)	Approx. Cable Weight	Standard Packing Length
Sq. mm	Ohm/Km	mm	mm	kg/km	Yard/Metre
0.5	39	0.8	3.0	12	100 Y
0.75	26	0.8	3.2	15	100 Y
1.0	19.5	0.8	3.4	18	100 Y
1.5	13.3	0.8	3.7	23	100 Y
2.5	7.98	0.8	4.2	33	100 Y
4.0	4.98	0.8	4.8	48	100 Y
6	3.3	0.8	6.3	70	100 Y
10	1.91	1.0	7.8	115	100 Y
16	1.21	1.0	9.0	170	100 Y
25	0.78	1.2	11.5	270	100 Y
35	0.554	1.2	13.0	365	1000 M
50	0.386	1.4	15.0	505	1000 M
70	0.272	1.4	17.5	700	1000 M
95	0.206	1.6	19.5	960	1000 M
120	0.0161	1.6	21.5	1200	1000 M
150	0.129	1.8	24.0	1510	1000 M
185	0.106	2.0	26.5	1830	1000 M
240	0.0801	2.2	30.0	2390	1000 M
300*	0.0641	2.4	32.0	2990	500 M
400*	0.0486	2.6	37.0	3940	500 M
500*	0.0384	2.8	41.0	5020	500 M
630*	0.0287	2.8	44.0	6070	250 M

- 300/500 V - FOUR CORE FLEXIBLE CORDS Copper Conductor PVC Insulated PVC Sheathed Flexible Cords (Cu/PVC/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Thickness of Outer Sheath	Mean Overall Diameter Max.	Approx. Cable Weight	Standard Packing Length
Sq. mm	Ohm/Km	mm	mm	mm	Kg/Km	Metre
0.75	26.0	0.6	0.8	8.6	90	100
1.0	19.5	0.6	0.9	9.4	105	100
1.5	13.3	0.7	1.0	11.0	150	100
2.5	7.98	0.8	1.1	13.0	210	100
4	4.95	0.8	1.2	14.0	290	1000
6*	3.30	0.8	1.4	17.0	430	1000
10*	1.91	1.0	1.4	20.5	660	1000
16*	1.21	1.0	1.4	23.5	925	1000

- 600/1000 V - Single Core Aluminum Conductor PVC Insulated Aluminum Wire Armoured PVC Sheathed Cables (Al/PVC/PVC/AWA/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Thickness of Extruded Bedding	Armour Wire Diameter	Thickness of Outer Sheath	Approx. Overall Diameter	Standard Packing Length
Sq. mm	Ohm/Km	mm	mm	mm	mm	mm	Metre ± 10%
50	0.641	1.4	1.0	1.6	1.8	20.6	500
70	0.443	1.4	1.0	1.6	1.8	22.4	500
95	0.320	1.6	1.0	1.6	1.8	24.6	500
120	0.253	1.6	1.0	1.6	1.8	26.0	500
150	0.206	1.8	1.0	1.6	1.8	27.8	500
185	0.164	2.0	1.0	1.6	1.8	29.9	500
240	0.125	2.2	1.0	1.6	1.9	33.0	500
300	0.100	2.4	1.2	2.0	2.0	36.7	500
400	0.0778	2.6	1.2	2.0	2.1	40.4	500
500	0.0605	2.8	1.2	2.0	2.2	43.9	500
630	0.0469	2.8	1.2	2.0	2.4	50.4	250
800	0.0367	2.8	1.4	2.5	2.5	56.3	250
1000	0.0291	3.0	1.4	2.5	2.7	61.6	250

- 600/1000 V - TWO CORE Aluminium Conductor PVC Insulated Steel wire Armoured PVC Sheathed Cable (Al/PVC/PVC/SWA/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Thickness of Extruded Bedding	Diameter of Armour Wire	Thickness of Outer Sheath	Approx. Overall Diameter	Standard Packing Length
Sq. mm	Ohm/Km	mm	mm	mm	mm	mm	Metre±10%
16	1.91	1.0	1.0	1.25	1.8	22.9	1000
25	1.20	1.2	1.0	1.6	1.8	27.0	500
35	0.868	1.2	1.0	1.6	1.8	29.2	500
50	0.641	1.4	1.0	1.6	1.9	32.9	500
70	0.443	1.4	1.2	2.0	2.0	37.7	500
95	0.320	1.6	1.2	2.0	2.2	42.5	500
120	0.253	1.6	1.2	2.0	2.3	45.5	500
150	0.206	1.8	1.4	2.5	2.4	50.7	500
185	0.164	2.0	1.4	2.5	2.6	55.2	250
240	0.125	2.2	1.6	2.5	2.8	61.9	250
300	0.100	2.4	1.6	2.5	2.9	66.8	250
400	0.0778	2.6	1.6	2.5	3.2	74.3	250
500	0.0366	2.8	1.8	3.15	3.4	83.0	200

- 300/500 V - TWO CORE Flexible CordsCopper conductor PVC Insulated PVC Sheathed Flexible Cords (Cu/PVC/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Thickness of Outer Sheath	Mean Overall Diameter Mex.	Standard Packing Length
Sq. mm	Ohm/Km	mm	mm	mm	Yard/Metre
0.5	39.0	0.6	0.8	7.0	100
0.75	26.0	0.6	0.8	7.6	100
1.0	19.5	0.6	0.8	8.0	100
1.25	15.6	0.7	0.8	8.6	100
1.5	13.3	0.7	0.8	9.0	100
2.5	7.98	0.8	1.0	11.0	100
4	4.95	0.8	1.1	12.0	100
6*	3.30	0.8	1.2	14.0	1000
10*	1.91	1.0	1.4	17.5	1000
16*	1.21	1.0	1.4	20.0	1000

- 600/1000 V - THREE CORE Copper Conductor PVC Insulated Steel Wire Armoured PVC Sheathed Cables (Cu/PVC/PVC/SWA/PVC and (Cu/PVC/SWA/PVC)

Nominal Area of Conductor	Maximum Conductor Resistance at 20°C	Thickness of Insulation	Thickness of Bedding		Diameter of Armour Wire	Thickness of Outer Sheath
			Extruded Bedding	Lapped Bedding		
Sq. mm	Ohm/Km	mm	mm		mm	mm
1.5*	12.1	0.7	0.8	-	0.9	1.4
1.5	12.1	0.7	0.8	-	0.9	1.4
2.5*	7.41	0.8	0.8	-	0.9	1.4
2.5	7.41	0.8	0.8	-	0.9	1.4
4	4.61	0.8	0.8	-	0.9	1.4
6	3.08	0.8	0.8	-	1.25	1.5
10	1.83	1.0	0.8	-	1.25	1.6
16	1.15	1.0	0.8	-	1.25	1.6
25	0.727	1.2	1.0	0.8	1.6	1.7
35	0.524	1.2	1.0	0.8	1.6	1.8
50	0.387	1.4	1.0	0.8	1.6	1.9
70	0.268	1.4	1.2	0.8	2.0	2.0
95	0.193	1.6	1.2	0.8	2.0	2.1
120	0.153	1.6	1.2	0.8	2.0	2.2
150	0.124	1.8	1.4	0.8	2.5	2.4
185	0.0991	2.0	1.4	0.8	2.5	2.5
240	0.0754	2.2	1.6	0.8	2.5	2.6
300	0.0601	2.4	1.6	0.8	2.5	2.8
400	0.0470	2.6	1.6	0.8	2.5	3.0
500	0.0366	2.8	1.8	0.8	3.15	3.6

- 600/1000 V - MULTICORE CABLE FOR STREET LIGHTING Copper Conductor XLPE Insulated PVC Sheathed cables (Cu/XLPE/PVC)

Cable Details	Nominal Area of Conductor		Max. Conductor Resistance at 20°C		Thickness of Insulation		Thickness of Outer Sheath	Approx. Overall Diameter	Approx. Cable Weight	Standard Packing Length
2x16+1x10	16	10	1.15	1.83	0.7	0.7	1.8	18.9	660	1000
3x25+2x16	25	16	0.727	1.15	0.9	0.7	1.8	27.2	1510	1000
3x35+2x16	35	16	0.524	1.15	0.9	0.7	1.8	30.2	1850	500

- 600/1000 V - FOUR CORE WITH REDUCED NEUTRAL Copper Conductor XLPE Insulated Steel Wire Armoured PVC Sheathed Cables (Cu/XLPE/PVC/SWA/PVC and Cu/XLPE/SWA/PVC)

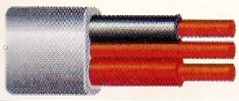
Nominal Area of Conductor		Max. Conductor Resistance at 20°C		Thickness of Insulation		Thickness of Bedding		Diameter of Armour Wire	Thickness of Outer Sheath	Approx. Overall Diameter	
10	6	1.83	3.08	0.7	0.7	1.0	-	1.25	1.8	22.0	-
16	10	1.15	1.83	0.7	0.7	1.0	-	1.25	1.8	24.7	-
25	16	0.727	1.15	0.9	0.7	1.0	0.8	1.6	1.8	26.6	25.3
35	16	0.524	1.15	0.9	0.7	1.0	0.8	1.6	1.8	30.0	28.9
50	25	0.387	0.727	1.0	0.9	1.0	0.8	1.6	1.9	33.1	32.0
70	35	0.268	0.524	1.1	0.9	1.2	0.8	2.0	2.0	37.8	36.3
95	50	0.193	0.387	1.1	1.0	1.2	0.8	2.0	2.1	42.1	40.6
120	70	0.153	0.268	1.2	1.1	1.2	0.8	2.0	2.2	45.5	44.0
150	70	0.124	0.268	1.4	1.1	1.4	0.8	2.5	2.4	52.0	50.1
185	95	0.0991	0.193	1.6	1.1	1.4	0.8	2.5	2.5	56.7	54.8
240	120	0.0754	0.153	1.7	1.2	1.6	0.8	2.5	2.6	62.0	59.7
300	150	0.0601	0.124	1.8	1.4	1.6	0.8	2.5	2.8	67.8	65.5
300*	185	0.0601	0.0991	1.8	1.6	-	0.8	2.5	2.8	-	65.9
300	185	0.0601	0.0991	1.8	1.6	1.6	0.8	2.5	2.8	67.8	65.5
400	185	0.0470	0.0991	2.0	1.6	1.6	0.8	2.5	3.0	75.0	72.7

- 600/1000 V - FOUR CORE WITH REDUCED NEUTRAL Aluminum Conductor XLPE Insulated Steel Wire Armoured PVC Sheathed Cables (Al/XLPE/PVC/SWA/PVC and Al/XLPE/SWA/PVC)

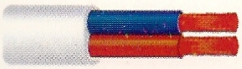
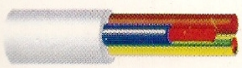
Nominal Area of Conductor		Max. Conductor Resistance at 20°c		Thickness of Insulation		Thickness of Bedding		Diameter of Armour Wire	Thickness of Outer Sheath	Approx. Overall Diameter	
35	16	0.868	1.91	0.9	0.7	1.0	0.8	1.6	1.8	29.7	28.6
50	25	0.641	1.20	1.0	0.9	1.0	0.8	1.6	1.9	33.1	32.0
70	35	0.443	0.868	1.1	0.9	1.2	0.8	2.0	2.1	38.0	36.5
95	50	0.320	0.641	1.1	1.0	1.2	0.8	2.0	2.2	42.1	40.6
120	70	0.253	0.443	1.2	1.1	1.2	0.8	2.0	2.3	45.7	44.2
150	70	0.206	0.443	1.4	1.1	1.4	0.8	2.5	2.5	50.4	48.5
185	95	0.164	0.320	1.6	1.1	1.4	0.8	2.5	2.7	56.4	54.5
240	120	0.125	0.253	1.7	1.2	1.6	0.8	2.5	2.9	62.8	60.5
300	150	0.100	0.206	1.8	1.4	1.6	0.8	2.5	3.0	68.2	65.9
300*	185	0.100	0.164	1.8	1.6	-	0.8	2.5	2.7	-	65.7
300	185	0.100	0.164	1.8	1.6	1.6	0.8	2.5	3.1	68.4	66.1
400	185	0.0778	0.164	2.0	1.6	1.6	0.8	3.15	3.3	76.9	74.6

5.1.8 Cables from PCC (Palstinian Cable Company)

- **Fixed installation cables :**

	Designation	Standard	Nominal voltage	Num. of cores	Cross sections mm^2	Application
FIXED INSTALLATION CABLES						
	NYM-J NYM-O	DIN VDE 0250 p. 204	300/500 V	1 2 - 4 5 7 10 - 12	1.5 - 16 1.5 - 35 1.5 - 16 1.5 - 2.5 1.5	For industrial and wiring purposes. Usable in the open, in dry, damp and wet environments in the open and concealed, as well as in masonry and in beton, not suitable for imbedding in solidified - or compressed concrete. Outdoor usage is only possible, as long as the cable is protected against direct sunlight.
	FR-N05VV-U FR-N05VV-R	NF C 32-207	300/500 V	2 - 4 5	1.5 - 35 1.5 - 25	
	EKK, FKK	SS 424 02 34	300/500 V	2 - 4 5	1.5 - 35 1.5 - 25	
	VMvK	KEMA K 36 C-4	450/750 V	1 2 - 4 5 6 - 61	1.5 - 300 1.5 - 35 1.5 - 25 1.5 - 2.5	
	PVC-insulated and PVC-sheathed cables with ECC	BS 6004	300/500 V	1 2 3	1 - 1.5 1 - 16 1 - 16	Fixed installation in dry or damp premises. Suitable for installation in walls, on boards and in channels or embedded in plaster.
	PVC-insulated and PVC-sheathed cables	BS 6004	300/500 V	1	1 - 35	

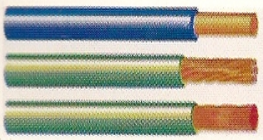
- **PVC sheated flexible cords:**

	H03VH-H	DIN VDE 0281 p. 302,	300/500 V	2	0.5 - 0.75	Flexible cords in domestic premises, kitchens, offices; for very light duties for light portable appliances.
	H03VV-F H03VVH2-F	BS 6500, NF C 32-201		2 - 4 2	0.5 - 0.75 0.5 - 0.75	
	H05VV-F	DIN VDE 0281 p. 402,	300/500 V	2 -5	0.75 - 4	Flexible cords in domestic premises, kitchens, offices; for household appliances, including damp situations; for medium duties (e.g. washing machines, refrigerators).
	H05VVH2-F	BS 6500, NF C 32-201		2	0.75 - 1	
	Heat resisting 85	BS 6141	300/300 V	2 - 3	0.5 - 0.75	The flexible cords contained within high temperature zones which are not subject to flexing or other mechanical stresses may be operated for a limited period, expressed in hours of cumulative operation,at a temperature exceeding the designated continuous operating temperature 90°C and maximum limited temperature 105°C.
	Heat resisting 85	BS 6141	300/500 V	2 - 4	0.5 - 2.5	

- **Power cables :**

	NYY	DIN VDE 0271	0.6/1 kV	1 3 4 5 7 - 40 3 + 1	10 - 300 1.5 - 25 1.5 - 35 1.5 - 25 1.5 - 2.5 25 + 16	PVC insulated and sheathed energy cables for use in the open air, underground, indoors and in cable ducts.
	NI2XY	DIN VDE 0262 (draft)	0.6/1 kV	1 3 4 5 7 - 40	10 - 35 1.5 - 16 1.5 - 35 1.5 - 10 1.5 - 2.5	XLPE insulated and PVC sheathed energy cables for use in the open air, indoors and in beton. Not for installation underground and water.
	N2XY	DIN VDE 0272 (draft)	0.6/1 kV	1 4 7 - 19 7 - 40	50 - 95 16 - 35 1.5 - 4 1.5 - 2.5	XLPE insulated and PVC sheathed energy cables for use in the open air, underground, indoors and in cable ducts.
	U-1000 R2V	NF C 32 321	0.6/1 kV	1 - 4 5 7 - 37 7 - 19	1.5 - 25 1.5 - 16 1.5 - 2.5 4	XLPE insulated and PVC sheathed energy cables for use in the open air, underground, indoors and in cable ducts.

- **PVC insulated signal core non – sheated cables :**

	H05V-U, H05V2 -U H05V-K, H05V2-K,	BS 6004, BS 6500 DIN VDE 0281 p.101, p. 102	300/500 V	1	0.5 - 1	H05V-U, H05V-K: suitable for installations in surface mounted or embedded conduits, only for signalling or control circuits. H05V2-U, H05V2-K: heat resistant cables for internal wiring only. Not suitable for fixed installations in distribution systems.
	H07V-U H07V-R H07V-K H07V2-U H07V2-K	BS 6004, DIN VDE 0281 p. 103 DIN VDE 0281 p. 108	450/750 V	1 1 1 1	1.5 - 300 1.5 - 300 1.5 - 240 1.5 - 2.5 1.5 - 2.5	H07V-U, H07V-R, H07V-K: suitable for use in channels with cover and for fixed protected installation in or on lighting fittings and inside appliances, switchgear and controlgear. H07V2-U, H07V2-K heat resistant cables for internal wiring only. Not suitable for fixed installations in distribution systems.

5.2 Cables selection criteria

We must be know excactly what is the kind of cables we need to used when we make our connections . some of circuits like power circuits need a thick cables we use it becouse of two reasons :

1- to reduse voltage drop .
2- to redused the resistance of cable .

5.2.1 How we can calculate the cable crossection arae that we need ?

❖ **We need to find the relationship between the current and the power**

- At one phase circuit :

$$I = \frac{P}{V \cos\theta.\eta} = \frac{746}{220(0.8)(0.9)} \approx 4.5hp$$

- At three phase circuit:

$$I = \frac{P}{\sqrt{3}V \cos\theta.\eta} = \frac{746}{\sqrt{3}\times 330(0.8)} \approx 1.55hp$$

❖ **Now we wanted to find ΔV :**

$$\Delta V = \frac{0.05\times V}{2L\times I}$$

- At one phase circuit :

$$\Delta V = \frac{5500}{L\times I} \text{ mv}$$

- At three phase circuit:

$$\Delta V = \frac{9500}{L\times I} \text{ mv}$$

❖ **Then we look at table below and find $\leq \Delta V$ from the table :**

Max rating (A)	Area (mm^2)	ΔV (mv)
10-16	**1.5**	**25**
20	**2.5**	**15**
25	**4**	**9.5**
35	**6**	**6.4**
50	**10**	**3.8**
63	**16**	**2.4**
80	**25**	**1.5**
100	**35**	**1.1**
125	**50**	**.82**
160	**70**	**.57**
200	**95**	**.42**
250	**120**	**.35**
300	**150**	**.29**
450	**185**	**.25**
500	**240**	**.21**
600	**300**	**.18**
770	**400**	**.17**
880	**500**	**.16**

5.2.2 Example : find the cable crossection that used to power on 5ohp pump that at 100 meters
of the source .

Sol :

❖ if one phase circuit we used :

$$I = 4.5Php$$

$$I = 4.5 \times 50 = 225A$$

Then we find ΔV :

$$\Delta V = \frac{5500}{L \times I}$$

$$\Delta V = \frac{5500}{100 \times 225} = 0.244 \text{ mv}$$

Now we look at table and find the kind of cable that at $\leq$ .244 mv.

It is 240mm^2. This cable has a rating of 500A which is > motor current. Therefore, it is Ok.

❖ If three phase circuit :

$$I = 1.5 \times Php$$
$$I = 1.5 \times 50 = 75A$$

Then we find ΔV :

$$\Delta V = \frac{9500}{L \times I}$$

$$\Delta V = \frac{9500}{100 \times 75} = 1.26$$

Now we look at table and find the kind of cable that at $\leq$ 1.26 .
It is 35mm^2. This cable has a rating of 100A which is > motor current. Therefore, it is Ok.

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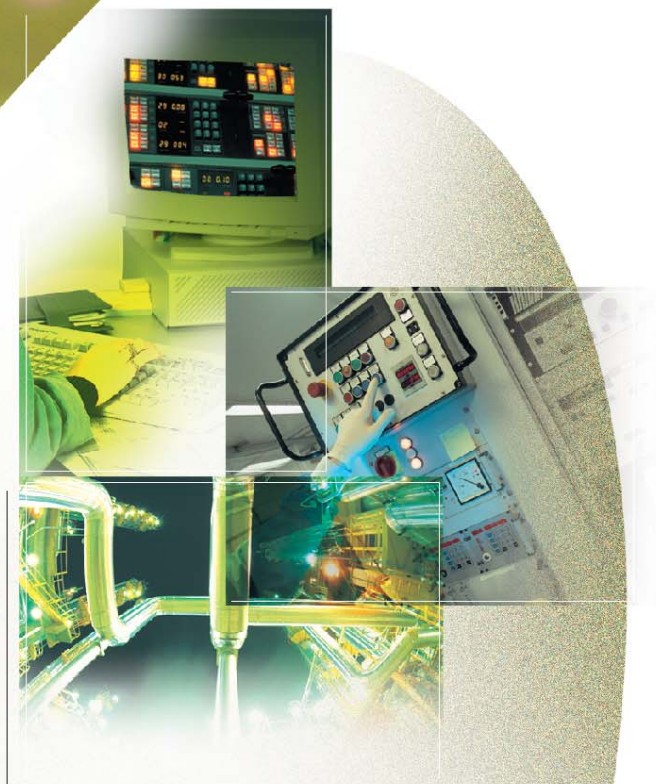


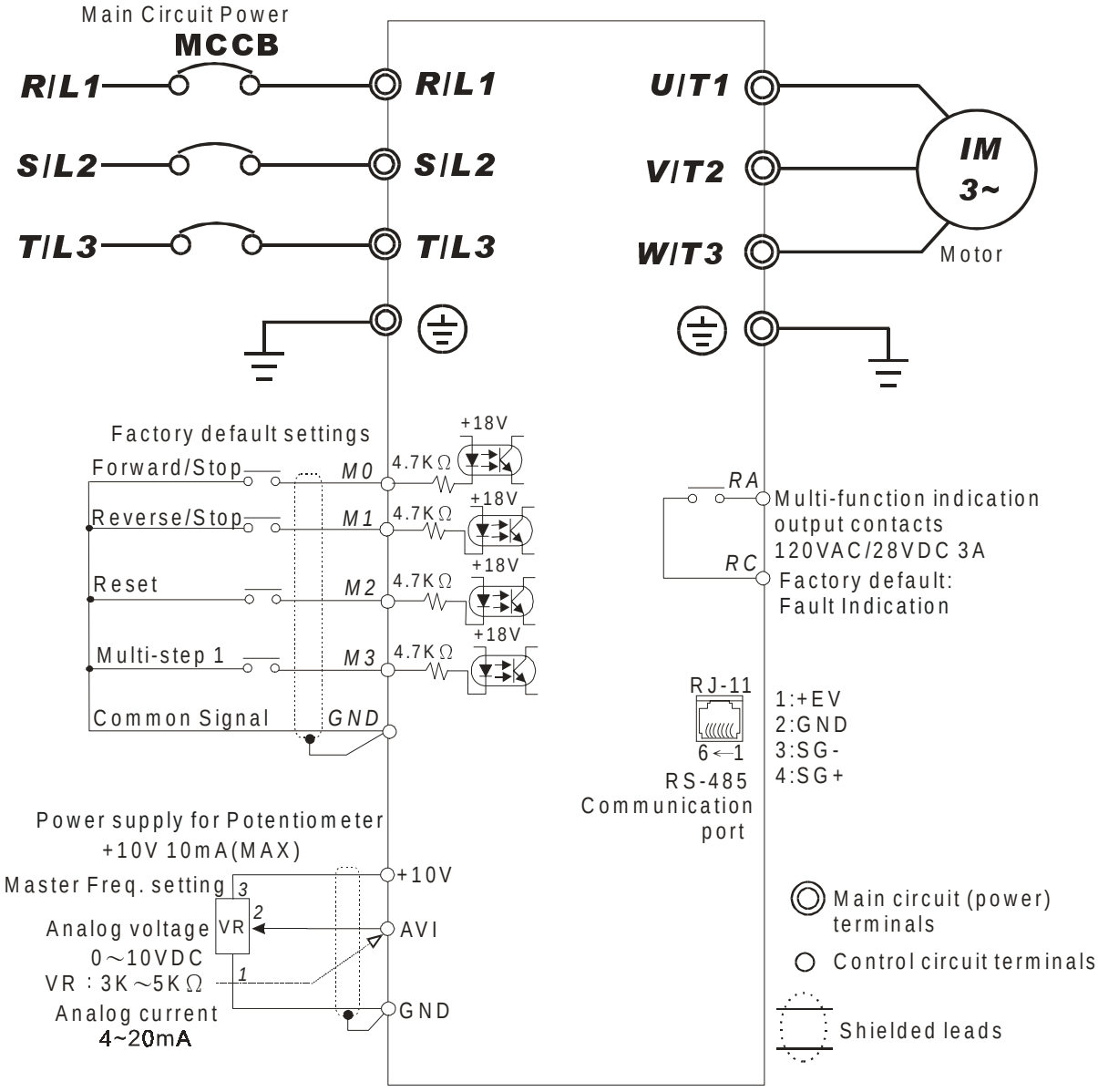
VFD-L | User Manual

Compact and Panel-installation Drives

115V 200W～400W
230V200W ～ 2HP

3.1 Basic Wiring Diagram

Users must connect wiring according to the circuit diagram shown below. Please follow all National and State wiring codes, when wiring the VFD-L.



NOTE: Do not plug in a Modem or telephone line to the RS-485 communication port, permanent damage may result. Terminals 1 & 2 are the power source for the optional copy keypad and should not be used while using RS-485 communication.

*If the AC Drive model is VFD002L11A/B, VFD004L11A/B, VFD002L21B, VFD004L21B or VFD007L21B, please use power terminals R/L1 and S/L2.

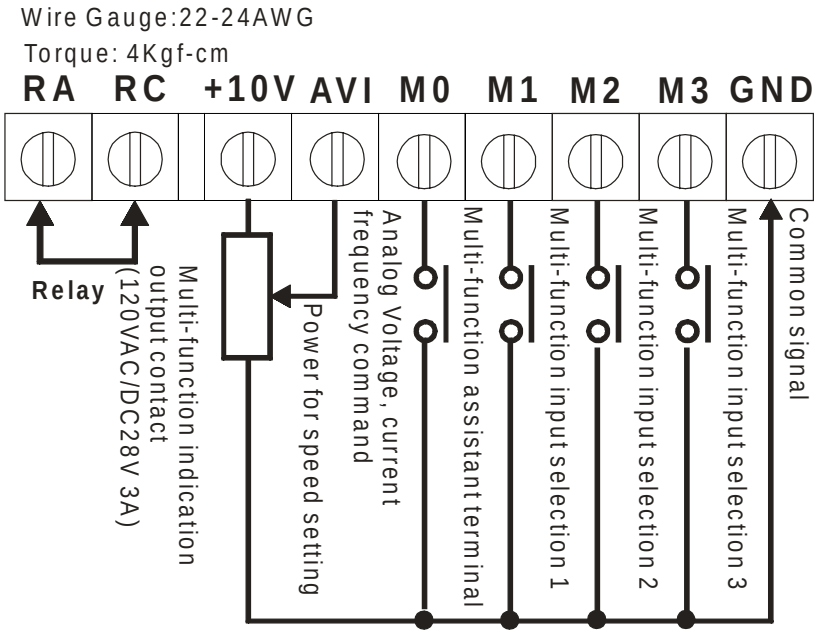
*If the AC Drive model is VFD002L21A, VFD004L21A or VFD007L21A, 3 phase power may be used on R/L1, S/L2, T/L3.

*If the AC Drive model is VFD015L23A, single phase power is not allowed.

3.2 Terminal Explanations

Terminal Symbol	Explanation of Terminal Function
R/L1, S/L2, T/L3	AC line input terminals
U/T1, V/T2, W/T3	AC drive output terminals motor connections
⏚	Earth Ground

3.3 Control Terminals Explanations



Terminal Symbols	Terminal Functions	Factory Settings
MI0	Multi-function Input 0	Refer to Pr.04-04 to Pr.04-06 Multi-function Input Terminals
MI1	Multi-function Input 1	
MI2	Multi-function Input 2	
MI3	Multi-function Input 3	
RA	Multi-function Relay output (N.O.) a	120Vac, 3A 24Vdc, 3A Refer to Pr.03-03
RC	Multi-function Relay common	
+10V	Potentiometer power source	+10V 20mA
AVI	Analog voltage/ Input current	0 to +10V / 4 to 20mA

* Control signal wiring size: 22-24 AWG (0.3-0.2 mm^2).

DELTA ELECTRONICS, INC.

VFD-S

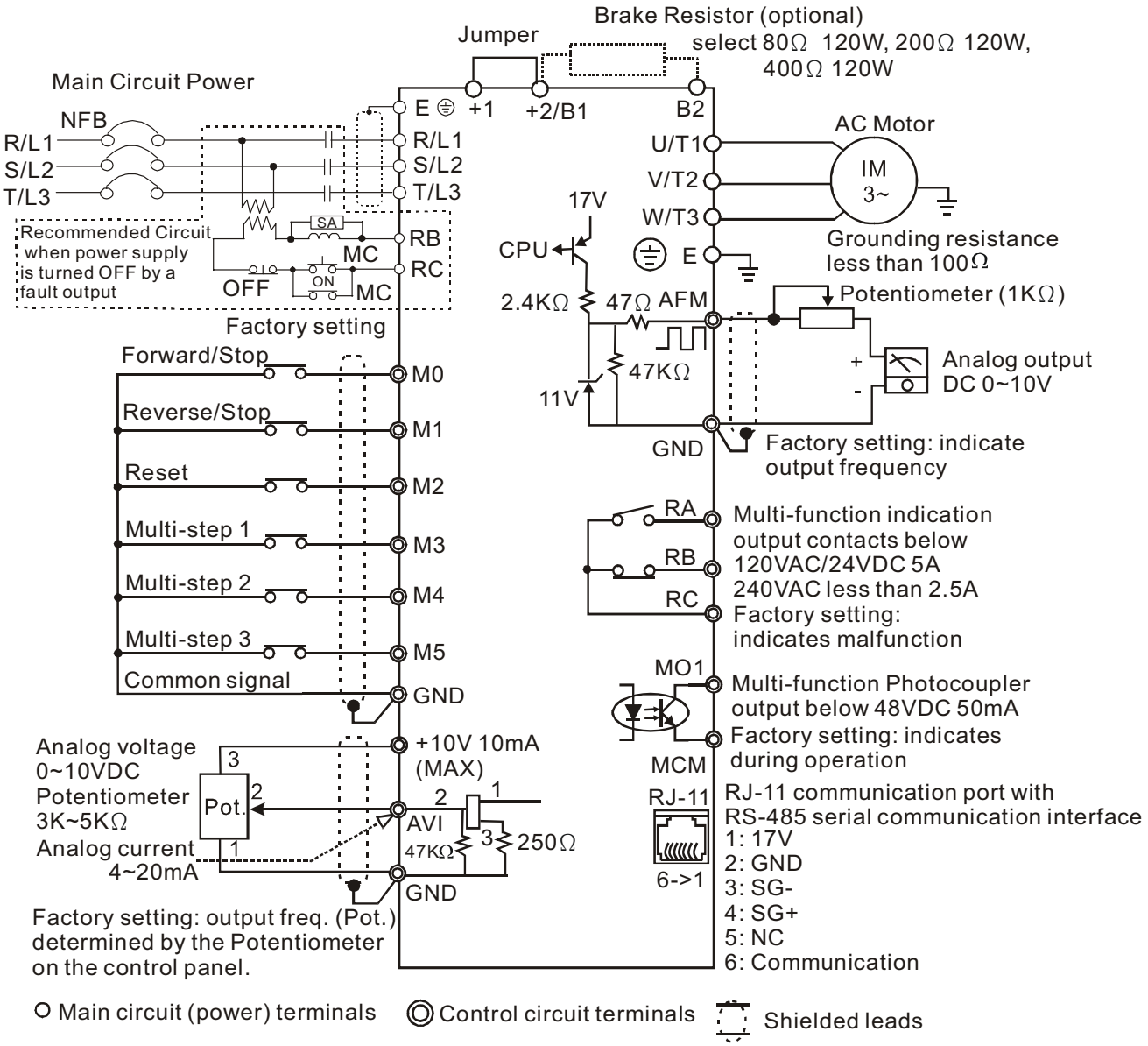
User Manual

Compact Low-Cost Easy-to-Use General-Purpose AC Motor Drives

Power Range:

1-phase 115V series:0.2kW~0.75kW (0.25~1.0HP)
3-phase 230V series:0.2kW~2.2kW (0.25~3.0HP)
3-phase 460V series:0.4kW~2.2kW (0.5~3.0HP)

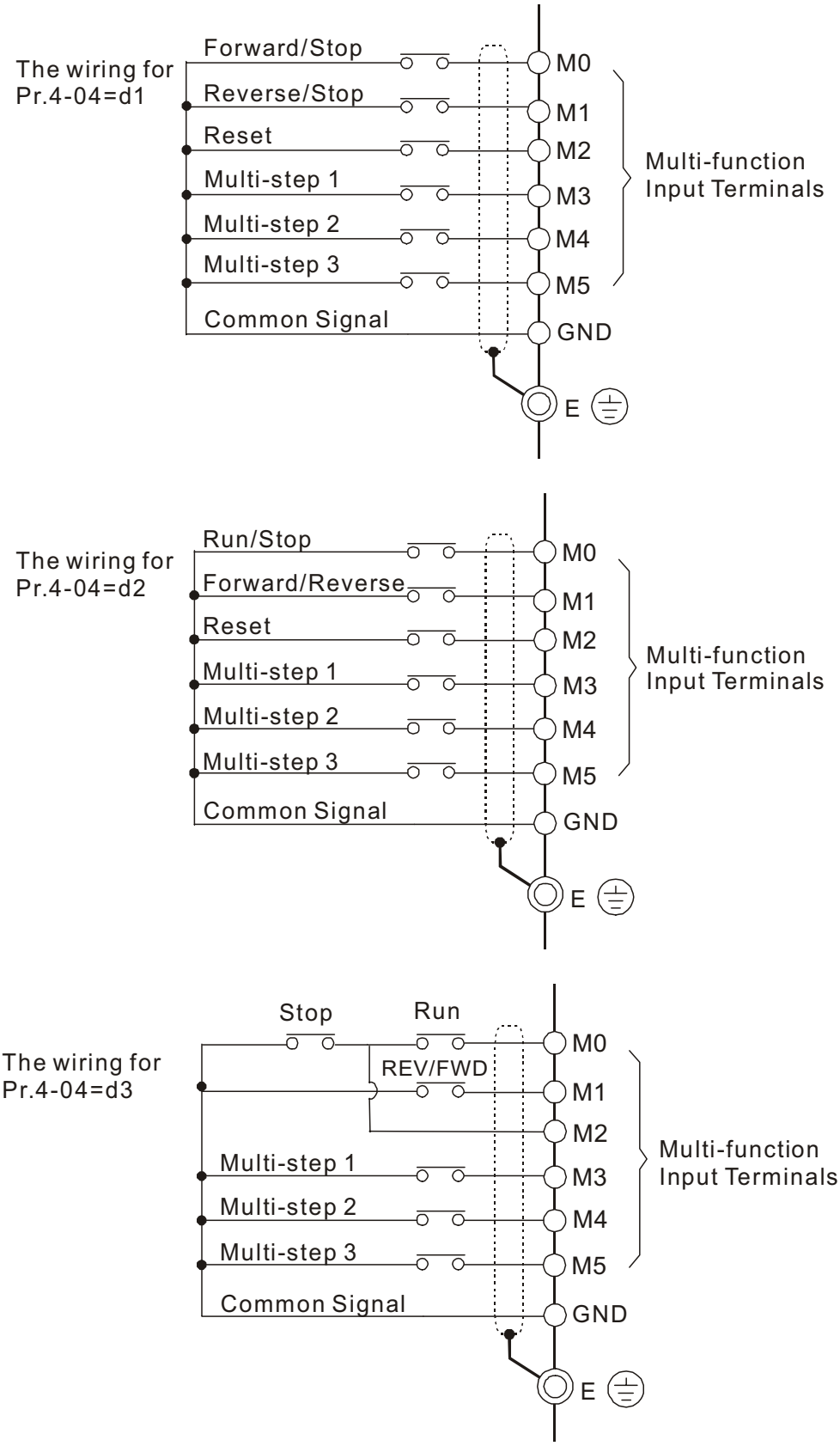
For VFDXXXSXXA/B/D/U



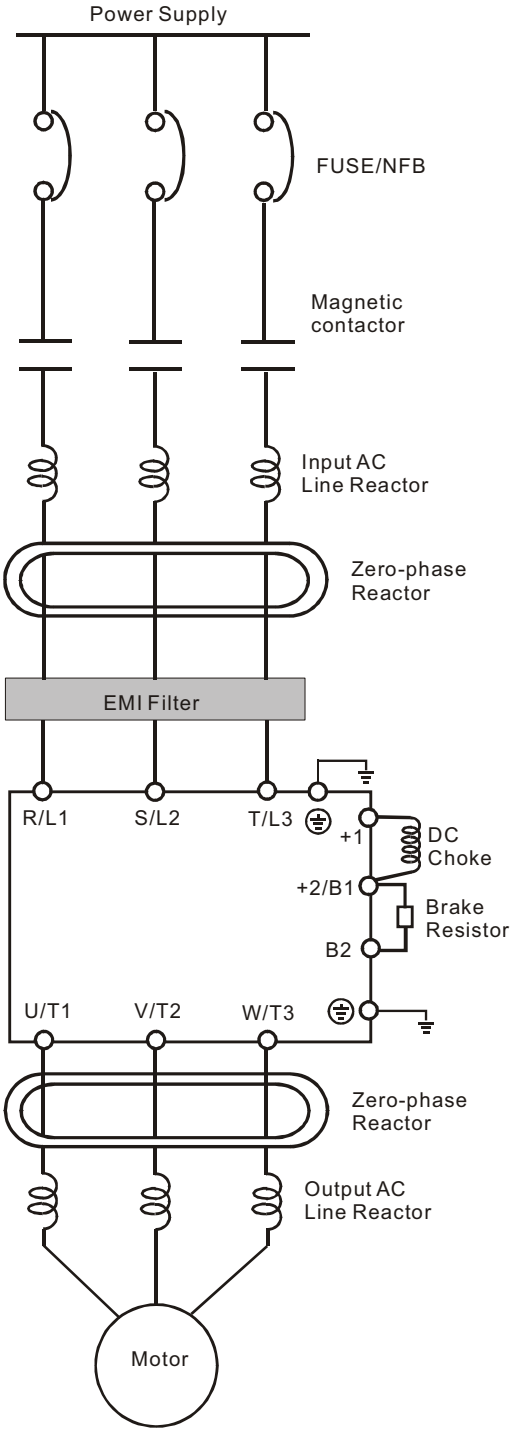
NOTE: Do not plug in a modem or telephone line to the RS-485 communication port, permanent damage may result. Pins 1&2 are the power sources for the optional copy keypad and should not be used while using RS-485 communication.

*If it is single phase model, please select any of the two input power terminals in main circuit power.

Two/Three wire control



2.4.2 External Wiring

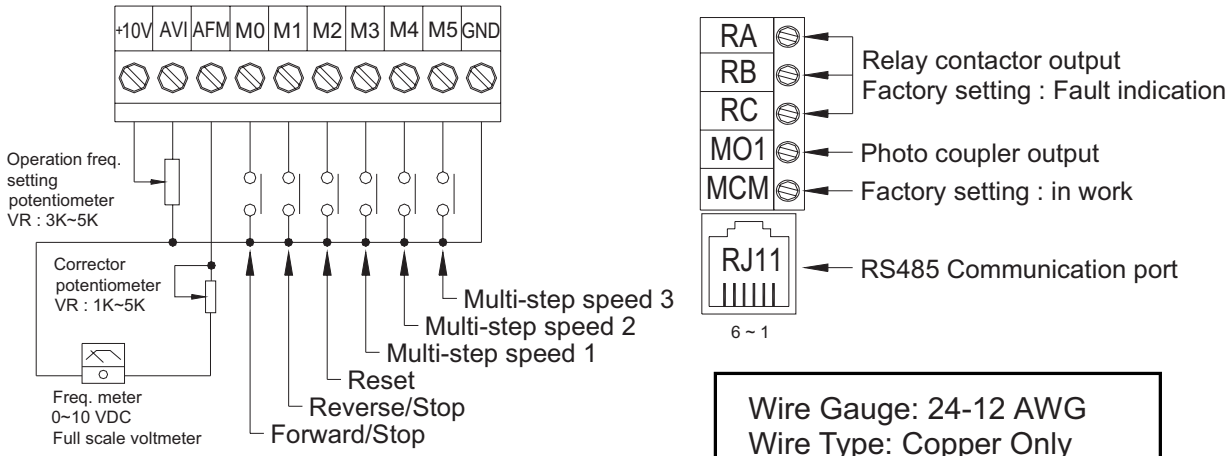


Items	Explanations
Power supply	Please follow the specific power supply requirements shown in Appendix A.
Fuse/NFB (Optional)	There may be an inrush current during power up. Please check the chart of Appendix B and select the correct fuse with rated current. Use of an NFB is optional.
Magnetic contactor (Optional)	Please do not use a Magnetic contactor as the I/O switch of the AC motor drive, as it will reduce the operating life cycle of the AC drive.
Input AC Line Reactor (Optional)	Used to improve the input power factor, to reduce harmonics and provide protection from AC line disturbances (surges, switching spikes, short interruptions, etc.). AC line reactor should be installed when the power supply capacity is 500kVA or more and or advanced capacity is activated. And the mains wiring distance should be $\leq$ 10m. Refer to Appendix B for details.
Zero-phase Reactor (Ferrite Core Common Choke) (Optional)	Zero phase reactors are used to reduce radio noise especially when audio equipment is installed near the inverter. Effective for noise reduction on both the input and output sides. Attenuation quality is good for a wide range from AM band to 10MHz. Appendix B specifies the zero phase reactor. (RF220X00A)
EMI filter (Optional)	To reduce electromagnetic interference, please refer to Appendix B for more details.
Brake resistor (Optional)	Used to reduce the deceleration time of the motor. Please refer to the chart in Appendix B for specific brake resistors.
Output AC Line Reactor (Optional)	Motor surge voltage amplitude depends on motor cable length. For applications with long motor cable (>20m), it is necessary to install a reactor at the inverter output side.

2.4.4 Control Terminals

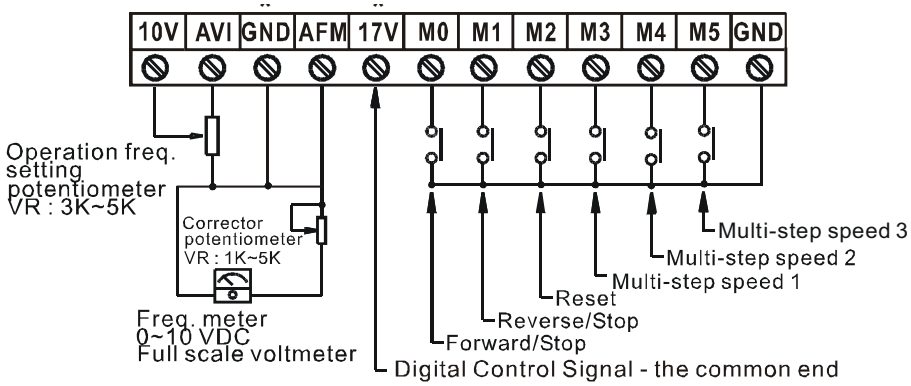
Control Terminal Wiring (Factory Setting)

A. XXXSXXA/B/D/U



Wire Gauge: 24-12 AWG
Wire Type: Copper Only
Torque: 4 kgf-cm (3.5 in-lbf)

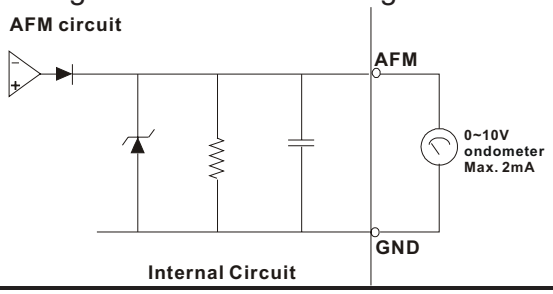
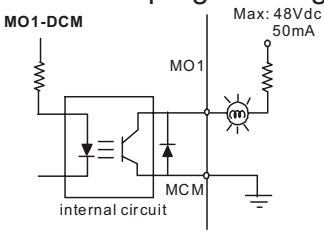
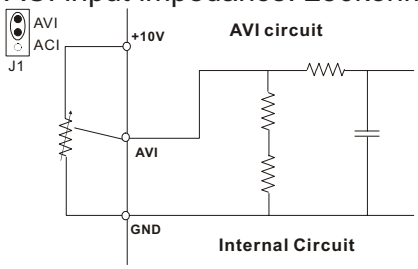
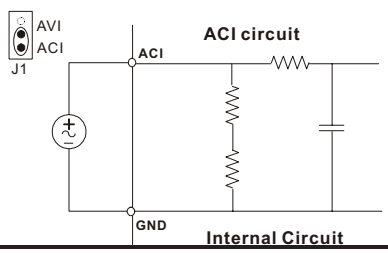
B. XXXSXXE



Wire Gauge: 24-16 AWG
Wire Type: Copper Only
Torque: 2 kgf-cm (1.7 in-lbf)

Terminal symbols and functions

Terminal Symbol	Terminal Function	Factory Settings (NPN mode) ON: Connect to GND
M0	Multi-function auxiliary input	Refer to Pr.4-04 to Pr.4-08 for programming the Multi-function Inputs. ON: the activation current is 16mA. OFF: leakage current tolerance is 10 μA.
M1	Multi-function input 1	
M2	Multi-function input 2	
M3	Multi-function input 3	
M4	Multi-function input 4	
M5	Multi-function Input 5	
+17V	DC Voltage Source	+17VDC, 20mA used for PNP mode.
GND	Digital Signal Common	Common for digital inputs and used for NPN mode.

Terminal Symbol	Terminal Function	Factory Settings (NPN mode) ON: Connect to GND
AFM	Analog output meter	The voltage output type for this analog signal is PWM, so this analog voltage is only suitable to connect an external movable coil meter, not suitable to connect a digital meter or for A/D signal conversion. 
RA	Multi-function Relay output (N.O.) a	Resistive Load: 5A(N.O.)/3A(N.C.) 240VAC 5A(N.O.)/3A(N.C.) 24VDC Inductive Load: 1.5A(N.O.)/0.5A(N.C.) 240VAC 1.5A(N.O.)/0.5A(N.C.) 24VDC Refer to Pr.3-06 for programming
RB	Multi-function Relay output (N.C.) b	
RC	Multi-function Relay common	
MO1	Multi-function Output 1 (Photocoupler)	Maximum 48VDC, 50mA Refer to Pr.3-01 for programming 
MCM	Multi-function output common	Max. 48Vdc 50mA
+10V	Potentiometer power supply	+10VDC 10mA (variable resistor: 3~5kohm)
AVI	Analog voltage Input (AVI/ACI)	0~+10V/4-20mA corresponds to 0-max. operation frequency (Pr.01-00) PID feedback signal AVI input impedance: 47kohm ACI input impedance: 250kohm  

Control signal wiring size: 18 AWG (0.75 mm^2) with shielded wire.

Chapter 5 Parameters

The VFD-S parameters are divided into 11 groups by property for easy setting. In most applications, the user can finish all parameter settings before start-up without the need for re-adjustment during operation.

The 11 groups are as follows:

Group 0: User Parameters
Group 1: Basic Parameters
Group 2: Operation Method Parameters
Group 3: Output Function Parameters
Group 4: Input Function Parameters
Group 5: Multi-Step Speed and PLC Parameters
Group 6: Protection Parameters
Group 7: Motor Parameters
Group 8: Special Parameters
Group 9: Communication Parameters
Group A: PID Parameters

5.1 Summary of Parameter Settings

✓: The parameter can be set during operation.

Group 0 User Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
0-00	Identity Code of the AC Motor Drive	Read-only	d #	
0-01	Rated Current Display of the AC Motor Drive	Read-only	d##.#	
0-02	Parameter Reset	d09: All parameters are reset to factory settings (50Hz, 220V/380V) d10: All parameters are reset to factory settings (60Hz, 220V/440V)	d0	
✓0-03	Start-up Display Selection	d0: Display the frequency command value (LED F) d1: Display the actual output frequency (LED H) d2: Multifunction display, see Pr.00-04 d3: Display output current (LED A) d4: Display forward/reverse command (Frd/rEv)	d0	
✓0-04	Content of Multi-Function Display	d0: Display User-Defined Unit (u) d1: Display Counter Value (C) d2: Display Process Operation (1.tt) d3: Display DC-BUS Voltage ($\bar{u}$) d4: Display output voltage (E) d5: Display frequency commands of PID (P) d6: Display analog feedback signal value (b) (%) d7: Display output voltage command (G)	d0	
✓0-05	User-Defined Coefficient K	d0.1 to d160	d1.0	
0-06	Software Version	Read-only	d#.#	
0-07	Password Input	d0 to d999	d0	
0-08	Password Set	d0 to d999	d0	
0-09	Memory Mode Selections	d0 to d63	d8	

Group 1 Basic Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
1-00	Maximum Output Frequency (Fmax)	d50.0 to d400 Hz	d60.0	
1-01	Maximum Voltage Frequency (Fbase)	d10.0 to d400 Hz	d60.0	
1-02	Maximum Output Voltage (Vmax)	230V series: d2.0V to d255V 460V series: d4.0V to d510V	d220 d440	
1-03	Mid-Point Frequency (Fmid)	d1.0 to d400 Hz	d1.0	

Pr.	Explanation	Settings	Factory Setting	NOTE
1-04	Mid-Point Voltage (Vmid)	230V series: d2.0V to d255V 460V series: d4.0V to d510V	d12 d24	
1-05	Minimum Output Frequency (Fmin)	d1.0 to d60.0 Hz	d1.0	
1-06	Minimum Output Voltage (Vmin)	230V series: d2.0V to d255V 460V series: d4.0V to d510V	d12.0 d24.0	
1-07	Output Frequency Upper Limit	d1 to d110%	d100	
1-08	Output Frequency Lower Limit	d0 to d100%	d0	
✓1-09	Accel Time 1	d0.1 to d600 Sec	d10.0	
✓1-10	Decel Time 1	d0.1 to d600 Sec	d10.0	
✓1-11	Accel Time 2	d0.1 to d600 Sec	d10.0	
✓1-12	Decel Time 2	d0.1 to d600 Sec	d10.0	
✓1-13	Jog Acceleration / Deceleration Time	d0.1 to d600 Sec	d10.0	
✓1-14	Jog Frequency	d1.0 Hz to d400 Hz	d6.0	
1-15	Auto acceleration / deceleration (refer to Accel/Decel time setting)	d0: Linear Accel/Decel d1: Auto Accel, Linear Decel d2: Linear Accel, Auto Decel d3: Auto Accel/Decel (Set by load) d4: Linear Accel; Auto Decel, Stall Prevention during Decel d5: Auto Accel/Decel, Stall Prevention during Decel	d0	
1-16	Acceleration S-Curve	d0 to d7	d0	
1-17	Deceleration S-Curve	d0 to d7	d0	
1-18	✓Jog Decelerating Time	d0.0 Jog Decelerating Time Determined by Pr.1-13 d0.1 to d600	d0.0	

Group 2 Operation Method Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
2-00	Source of Master Frequency Command	d0: Master Frequency input determined by digital keypad. (record the frequency of power loss and it can do analog overlap plus) d1: Master Frequency determined by analog signal DC 0V-10V (external terminal AVI). (won't record the frequency of power loss and it can't do analog overlap plus) d2: Master Frequency determined by analog signal DC 4mA - 20mA (external terminal AVI). (won't record the frequency of power loss and it can't do analog overlap plus)	d0	

Pr.	Explanation	Settings	Factory Setting	NOTE
2-00	Source of Master Frequency Command	d3: Master Frequency determined by Potentiometer on the digital keypad. (won't record the frequency of power loss and it can do analog overlap plus) d4: Master Frequency operated by RS-485 serial communication interface and record frequency of power loss. (record the frequency of power loss and it can do analog overlap plus) d5: Master Frequency operated by RS-485 serial communication interface and won't record frequency before power loss. (won't record the frequency of power loss and it can do analog overlap plus)	d0	
2-01	Source of Operation Command	d0: Digital Keypad d1: External terminals. Keypad STOP/RESET enabled. d2: External terminals. Keypad STOP/RESET disabled. d3: RS-485 serial communication (RJ-11) .Keypad STOP/RESET enabled. d4: RS-485 serial communication (RJ-11). Keypad STOP/RESET disabled.	d0	
2-02	Stop Method	d0: STOP: ramp to stop; E.F.: coast to stop d1: STOP: coast to stop; E.F.: coast to stop	d0	
2-03	PWM Carrier Frequency Selections	d3: 3KHz d4: 4KHz d5: 5KHz d6: 6KHz d7: 7KHz d8: 8KHz d9: 9KHz d10: 10KHz	d10	
2-04	Motor Direction Control	d0: Enable forward/reverse operation d1: Disable reverse operation	d0	
2-05	Loss of ACI Signal	d0: Decelerate to 0 Hz d1: Coast to stop and display "EF" d2: Continue operation by last frequency command	d0	
2-06	Analog Auxiliary Frequency Operation	d0: Disable d1: Enable + AVI d2: Enable + ACI	d0	

Group 3 Output Function Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
3-00	Analog Output Signal	d0: analog frequency meter d1: analog current meter	d0	
✓3-01	Analog Output Gain	d1 to d200%	d100	
3-02	Desired Frequency Attained	d1.0 to d400 Hz	d1.0	
3-03	Terminal Count Value	d0 to d999	d0	
3-04	Preliminary Count Value	d0 to d999	d0	
3-05	Multi-Function Output Terminal 1 (Photocoupler Output)	d0: No Function	d1	
3-06	Multi-Function Output Terminal 2 (Relay Output)	d1: AC Drive Operational d2: Master Frequency Attained d3: Zero Speed d4: Over Torque Detection d5: Base-Block (B.B.) Indication d6: Low-Voltage Indication d7: Operation Mode Indication d8: Fault Indication d9: Desired Frequency Attained d10: PLC Program Running d11: PLC Program Step Completed d12: PLC Program Completed d13: PLC Program Operation Paused d14: Terminal Count Value Attained d15: Preliminary Count Value Attained d16: AC Motor Drive Ready d17: FWD command Indication d18: REV command Indication	d8	

Group 4 Input Function Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
✓4-00	Potentiometer Bias Frequency	d 0.0 to d 100.0%	d0.0	
✓4-01	Potentiometer Bias Polarity	d0: Positive Bias d1: Negative Bias	d0	
✓4-02	Potentiometer Frequency Gain	d1 to d200 %	d100	
4-03	Potentiometer Reverse Motion Enable	d0: Forward Motion Only d1: Reverse Motion enabled	d0	

Pr.	Explanation	Settings	Factory Setting	NOTE
4-04	Multi-Function Input Terminal 1 (M0, M1)	d0: No Function d1: FWD/STOP, REV/STOP d2: FWD/REV, RUN/STOP d3: 3-wire Operation Control Mode d4: E.F. External Fault Input (N.O.) d5: E.F. External Fault Input (N.C.) d6: Reset d7: Multi-Step Speed Command 1 d8: Multi-Step Speed Command 2 d9: Multi-Step Speed Command 3 d10: Jog Operation d11: Accel/decel Inhibit d12: First or Second Acceleration/deceleration Time Selection d13: External base block (N.O.) d14: External base block (N.C.) d15: Up: Increment master frequency d16: Down: Decrement master frequency d17: Run PLC Program d18: Pause PLC Program d19: Counter Trigger Signal d20: Counter Reset d21: Select ACI / Deselect AVI d22: PID Function Disabled d23: JOG FWD d24: JOG REV d25: The source of master frequency is AVI. d26: The source of master frequency is ACI. d27: Press UP/DOWN key to switch forward/reverse (N.O.) motion d28: Press UP/DOWN key to switch forward/reverse (N.C.) motion d29: M0: 0: RUN 1: STOP, M1: no function, Direction is controlled by keypad	d1	
4-05	Multi-Function Input Terminal 2 (M2)		d6	
4-06	Multi-Function Input Terminal 3 (M3)		d7	
4-07	Multi-Function Input Terminal 4 (M4)		d8	
4-08	Multi-Function Input Terminal 5 (M5)		d9	
4-09	Line Start Lockout	d0: Disable d1: Enable	d0	
4-10	Up/Down Mode	d0: Based on accel/decel time d1: Up frequency according to constant speed, down frequency according to deceleration time d2: Up frequency according to acceleration time, down frequenc according to constant speed d3: Constant speed	d3	
4-11	Accel/Decel Rate of Change of UP/DOWN Operation with Constant Speed	0~1000, unit: 5 Hz/sec	d1	

Group 5 Multi-Step Speed and PLC Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
5-00	1st Step Speed Freq.	d0.0 to d400 Hz	d0.0	
5-01	2nd Step Speed Freq.	d0.0 to d400 Hz	d0.0	
5-02	3rd Step Speed Freq.	d0.0 to d400 Hz	d0.0	
5-03	4th Step Speed Freq.	d0.0 to d400 Hz	d0.0	
5-04	5th Step Speed Freq.	d0.0 to d400 Hz	d0.0	
5-05	6th Step Speed Freq.	d0.0 to d400 Hz	d0.0	
5-06	7th Step Speed Freq.	d0.0 to d400 Hz	d0.0	
5-07	PLC Mode	d0: Disable PLC Operation d1: Execute one program cycle d2: Continuously execute program cycles d3: Execute one program cycle step by step d4: Continuously execute one program cycle step by step d5: Disable PLC operation, but can set direction of 1st speed to 7th speed	d0	
5-08	PLC Forward/ Reverse Motion	d0 to d255 (0: FWD 1: REV)	d0	
5-09	Time Duration of Master Speed	d0 to d65500 Sec	d0	
5-10	Time Duration of 1st Step Speed	d0 to d65500 Sec	d0	
5-11	Time Duration of 2nd Step Speed	d0 to d65500 Sec	d0	
5-12	Time Duration of 3rd Step Speed	d0 to d65500 Sec	d0	
5-13	Time Duration of 4th Step Speed	d0 to d65500 Sec	d0	
5-14	Time Duration of 5th Step Speed	d0 to d65500 Sec	d0	
5-15	Time Duration of 6th Step Speed	d0 to d65500 Sec	d0	
5-16	Time Duration of 7th Step Speed	d0 to d65500 Sec	d0	

Group 6 Protection Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
6-00	Over-Voltage Stall Prevention	d0: Disable d1: Enable	d1	
6-01	Over-Voltage Stall Prevention Level	115V/230V series: d350 to d410V 460V series: d700 to d820V	d390 d780	
6-02	Over-Current Stall Prevention Level	d20 to d150%	d130	
6-03	Over-Torque Detection Mode	d0: Disabled d1: Enabled during constant speed operation. After the over-torque is detected, keep running until OL1 or OL occurs. d2: Enabled during constant speed operation. After the over-torque is detected, stop running. d3: Enabled during running and continues before Continuous Output Time Limit (Pr.6-05) is reached.	d0	

Pr.	Explanation	Settings	Factory Setting	NOTE
		d4: Enabled during running. After the over-torque is detected, stop running.		
6-04	Over-Torque Detection Level	d30 to d200%	d150	
6-05	Over-Torque Detection Time	d0.1 to d10.0 Sec	d0.1	
6-06	Electronic Thermal Overload Relay Selection	d0 to d2	d2	
↗6-07	Electronic Thermal Characteristic	d30 to d600 Sec	d60	
6-08	Present Fault Record	d0: No fault d1: Over current (oc) d2: Over voltage (ov) d3: Over heat (oH) d4: Over load (oL) d5: Over load (oL1) d6: External fault (EF) d7: Reserved d8: Reserved d9: Excess current during acceleration (ocA) d10: Excess current during deceleration (ocd) d11: Excess current during steady state (ocn) d12: Ground fault (GF) d13: Reserved d14: Low voltage (Lv) d15: CPU failure 1 (cF1) d16: CPU failure 2 (cF2) d17: Base block (b.b.) d18: Overload (oL2) d19: Auto acceleration/deceleration failure (cFA) d20: Software protection enable (codE) d21: Reserved d22: CPU failure (cF3.1) d23: CPU failure (cF3.2) d24: CPU failure (cF3.3) d25: CPU failure (cF3.4) d26: CPU failure (cF3.5) d27: CPU failure (cF3.6) d28: CPU failure (cF3.7) d29: Hardware protection failure (HPF.1) d30: Hardware protection failure (HPF.2) d31: Hardware protection failure (HPF.3) d32: Communication time-out (CE10) d33: Reserved d34: Software error (SErr)	d0	
6-09	Second Most Recent Fault Record			
6-10	Third Most Recent Fault Record			

Pr.	Explanation	Settings	Factory Setting	NOTE
		d35: Reserved d36: PID error (Pld) d37: Reserved d38: Phase loss (PHL)		

Group 7 Motor Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
✓7-00	Motor Rated Current	d30 to d120%	d85	
✓7-01	Motor No-Load Current	d0 to d90%	d50	
✓7-02	Torque Compensation	d0 to d10	d1	
✓7-03	Slip Compensation	d0.0 to d10.0	d0.0	

Group 8 Special Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
8-00	DC Brake Voltage Level	d0 to d30%	d0	
8-01	DC Brake Time during Start-Up	d0.0 to d60.0 Sec	d0.0	
8-02	DC Brake time during Stopping	d0.0 to d60.0 Sec	d0.0	
8-03	Start-Point for DC Brake	d0.0 to d400 Hz	d0.0	
8-04	Momentary Power Loss Operation Selection	d0: Operation stops after Momentary Power Loss d1: Operation continues after momentary power loss, speed search starts with the Master Frequency reference value d2: Operation continues after momentary power loss, speed search starts with the minimum frequency	d0	
8-05	Maximum Allowable Power Loss Time	d0.3 to d5.0 Sec	d2.0	
8-06	B.B. Time for Speed Search	d0.3 to d5.0 Sec	d0.5	
8-07	Current Limit for Speed Search	d30 to d200%	d150	
8-08	Skip Frequency 1 Upper Limit	d0.0 to d400 Hz	d0.0	
8-09	Skip Frequency 1 Lower Limit	d0.0 to d400 Hz	d0.0	
8-10	Skip Frequency 2 Upper Limit	d0.0 to d400 Hz	d0.0	
8-11	Skip Frequency 2 Lower Limit	d0.0 to d400 Hz	d0.0	
8-12	Skip Frequency 3 Upper Limit	d0.0 to d400 Hz	d0.0	
8-13	Skip Frequency 3 Lower Limit	d0.0 to d400 Hz	d0.0	
8-14	Auto Restart After Fault	d0 to d10	d0	
8-15	AVR Function	d0: Enable d1: Disable d2: Disable when deceleration	d2	
8-16	Software Brake Level	115V/230V series: d350 to d450V 460V series: d700 to d900V	d380 d760	
8-17	DC Brake Lower Bound Limit	d0.0 to d400 Hz	d0.0	

Group 9 Communication Parameters

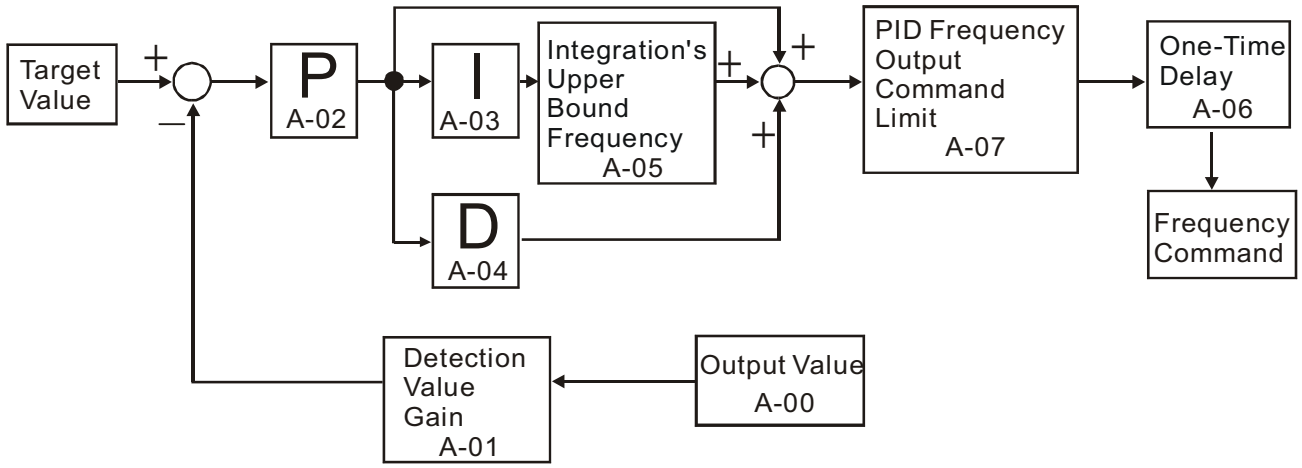
Pr.	Explanation	Settings	Factory Setting	NOTE
✓9-00	Communication Address	d1 to d254	d1	
✓9-01	Transmission Speed	d0: Baud Rate 4800 bps d1: Baud Rate 9600 bps d2: Baud Rate 19200 bps d3: Baud Rate 38400 bps	d1	
✓9-02	Transmission Fault Treatment	d0: Warn and Keep Operating d1: Warn and Ramp to Stop d2: Warn and Coast to Stop d3: Keep Operating without Warning	d0	
✓9-03	Time-out Detection	d0: Disable d1 to d20: time setting (1 sec increment)	d0	
✓9-04	Communication Protocol	d0: 7,N,2 (Modbus, ASCII) d1: 7,E,1 (Modbus, ASCII) d2: 7,O,1 (Modbus, ASCII) d3: 8,N,2 (Modbus, ASCII) d4: 8,E,1 (Modbus, ASCII) d5: 8,O,1 (Modbus, ASCII) d6: 8,N,2 (Modbus, RTU) d7: 8,E,1 (Modbus, RTU) d8: 8,O,1 (Modbus, RTU)	d0	

Group A PID Parameters

Pr.	Explanation	Settings	Factory Setting	NOTE
A-00	Input terminal for PID Feedback	d0: Disable PID function d1: Negative PID feedback from external terminal (AVI) 0 to +10V d2: Negative PID feedback from external terminal (ACI) 4 to 20mA d3: Positive PID feedback from external terminal (AVI) 0 to +10V d4: Positive PID feedback from external terminal (ACI) 4 to 20mA	d0	
A-01	Gain over PID Detection value	d0 to d999	d100	
A-02	Proportional Gain (P)	d0 to d999	d100	
A-03	Integral Time (I)	d0 to d999	d100	
A-04	Derivative Control (D)	d0 to d100	d0	
A-05	Upper Bound for Integral Control	d0 to d100%	d100	
A-06	Primary Delay Filter Time	d0 to d999	d0	
A-07	PID Output Freq. Limit	d0 to d110%	d100	
A-08	Feedback Signal Detection Time	d0.0 to d650 seconds	d0.0	

Pr.	Explanation	Settings	Factory Setting	NOTE
A-09	Treatment of the Erroneous Feedback Signals	d0: warn and RAMP to stop d1: warn and COAST to stop	d0	
A-10	Sleep Frequency	d0.0 to d400Hz	d0.0	
A-11	Wakeup Frequency	d0.0 to d400Hz	d0.0	
A-12	Sleep Period	d0.0 to d650 seconds	d0.0	
A-13	PID User Defined	d0.0 to d400	d0.0	

the setting frequency of parameters, such as Max. operation frequency, 1st speed and etc., they are still needed to set with actual value.



If the input range of sensor is 0~SI_max, output range is SO_min~SO_max and then $\frac{\text{Input}}{\text{Per output}}$ is $\frac{\text{SI\_max}}{\text{SO\_max-SO\_min}}$, set drive input to sensor output

Set input range of drive is D_range= 10V(0~10V) or 16mA (4~20mA) that correspond to 0~1-00Hz and then $\frac{\text{Output}}{\text{Per input}}$ will be $\frac{\text{1-00}}{\text{D\_range}}$

According to the display value of F and H = actual value ×A-13/1-00, and then $\frac{\text{Display value of F, H}}{\text{Actual value}}$ =A-13/1-00. If you want the result to be display value = sensor output and actual value = drive output, and then

$$\frac{\text{A-13}}{\text{1-00}} = \frac{\frac{\text{SI\_max}}{\text{SO\_max-SO\_min}} \times \frac{\text{A-01}}{100}}{\frac{\text{1-00}}{\text{D\_range}}} \Rightarrow \text{A-13} = \frac{\text{SI\_max}}{\text{SO\_max-SO\_min}} \times \frac{\text{A-01}}{100} \times \text{D\_range}$$

Example:

Sensor: 0~6 psi input corresponds to 0~5V output drive AVI: 0~10V input corresponds to 0~60Hz, A-01=100

$$\text{A-13} = \frac{6}{5\text{-}0} \times \frac{100}{100} \times 10 = 12$$

The Islamic University-Gaza
Electrical Engineering Department

CH7
Generators boards

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December/2009

Table of content

Introduction to Generators

7.1.1 Types of Generators

Generators are used for the generation of electricity and they ensure that most of the essential appliances can be run whenever there is a power outage.

There are two basic types of generators:

- **Stand By**

Stand by generators provide backup power in homes and offices and are permanently installed outside the house or office building they are plugged into the electric circuits or home wiring.
The unit turns itself on and off automatically.
They can automatically detect disruption in the usual electric supply and begin supplying power within a few seconds.

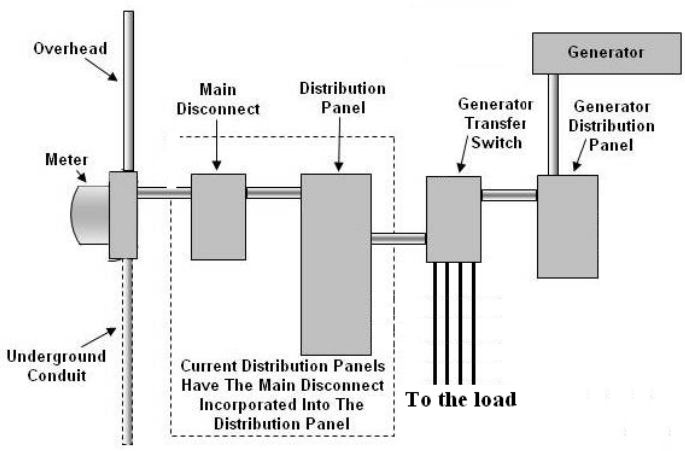

Fig. 7.1 Block diagram to standby generator

- **Portable**

Portable generators are usually used in places where there is no power supply such as construction sites, camps, etc. These generators are sufficient to run appliances like televisions, refrigerators, sump pumps and furnaces. Portable systems are wheeled units that require to roll the generator outside, start it up, and hook it up to a power inlet box Portable generators supply electricity to selected appliances through extension cords.

7.1.2 How to choose a generator

When we want to buy a generator, we must know the specifications required and available to be used all the possibilities **.**

Must meet the following specifications**:**

- The required number of phase(one phase or three phase) .
- The maximum power required .
- We want use it stand by or Portable .

7.1.3 Equivalent circuits for generator

The equivalent circuit :

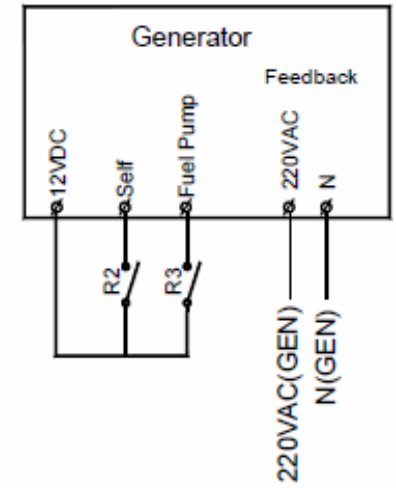

Fig. 7.2 equivalent circuit

To control the generator must be built to run self panel :

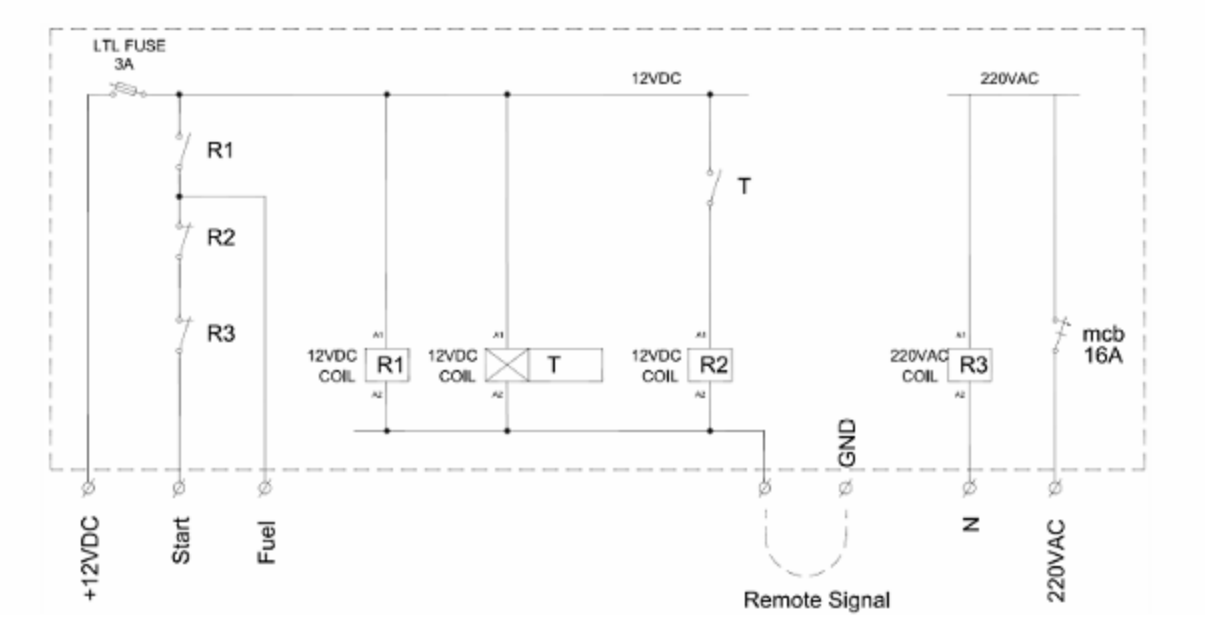

Fig. 7.3 self start generator

Change over panel

7.2.1 Introduction

Just a few years ago, the thought of owning an emergency standby generator seemed preposterous and living without electricity is all too common.

But now many homeowners simply cannot afford to ride out another power outage. Instead, they are installing home standby generators in record numbers to protect their families and investments.

What is the change over ?

The change over is the process of converting electricity from one source to another in the event of a defection one of the sources and the conversion of either the main line to the generator and either of the main line to the ups and the conversion process .

Where we use it ?

- Factory .
- home .
- public institutions .
- private institutions .

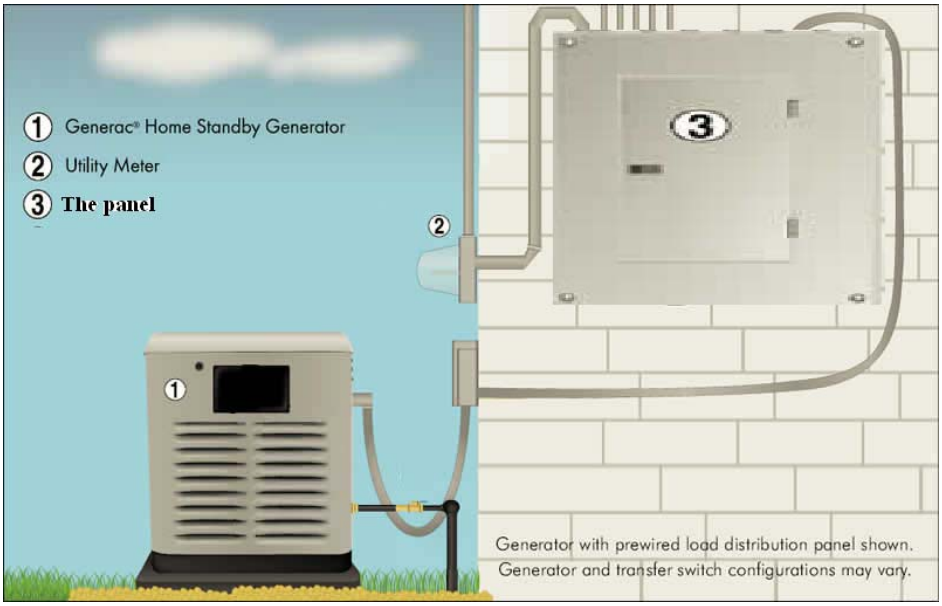

Fig 7.4 Picture showing the connection for generator in ma in source

7.1.2 Change over power circuit

The power circuit of change over switch consists of two mechanically interlocked contactors, CM for the main source and CG for the generator**.**

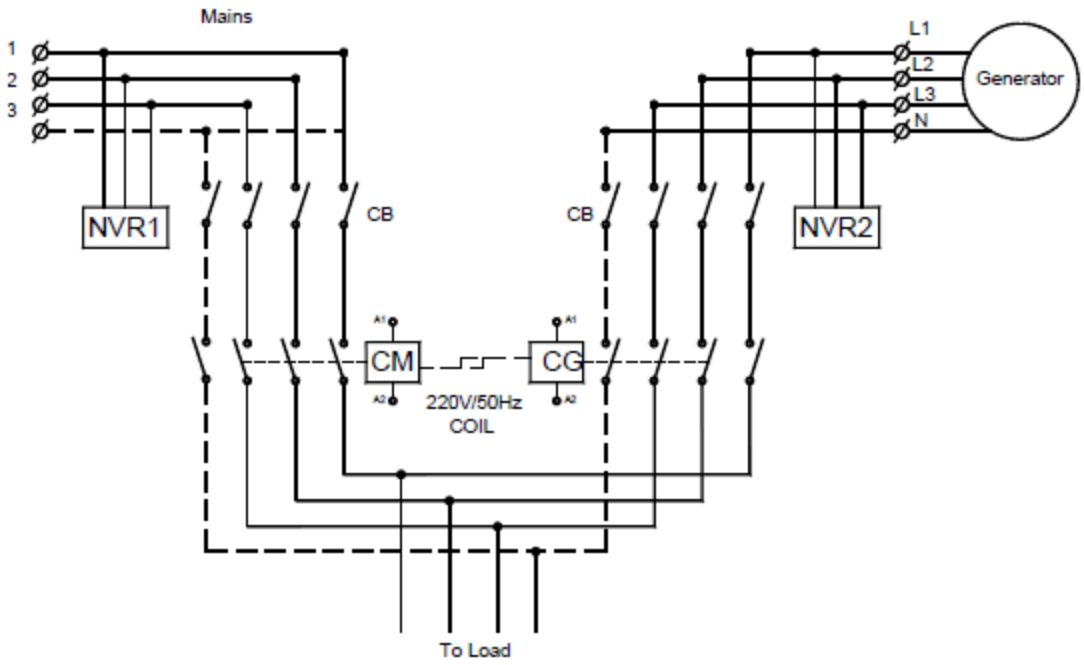

Fig. 7.5 Power circuit diagram for a change over switch

Why we use the mechanically interlocked contactors ?
To protect the power network from overlap between the power sources .
This device prevents the work of one contactors if the other is in operation

Fig 7.6 mechanically interlocked contactors

When the design is high power we use the motorized contactor ,in Gaza strip we use NZM2-XR

Fig 7.7 motorized contactor

7.1.3 Change over control circuit

A transfer switch allows safe switching between your mains supply (primary source) and your standby generator supply (secondary source) whilst ensuring both sources cannot be connected simultaneously.

Transfer switches can be manual or automatic and switch between multiple power sources،it can be very simple or very sophisticated in design and operation. it can send power to a single circuit or can be part of a panel that supplies multiple circuits.

There are two ways to do the change over process:
1- Manual Transfer Switch (MTS)
2- Automatic Transfer Switch (ATS)

Fig 7.8 MTS panel

Manual Transfer Switch (MTS) are generally the least expensive and least complicated of the two types of transfer switches. MTS's require someone to be on-site to start and shut down the generator and physically operate the MTS.

Manual transfer switches come in various sizes and different configurations to suit your specific application. Both portable and stationary generators may use manual transfer switch equipment.

A manual transfer switch features a three position selector switch .
It may also be fitted with warning lights, or some other method of indicating whether the mains/generator supply is available .
The first position will make the connection between the mains supply and the distribution board. This is the default position for the transfer switch when the mains supply is healthy.

The second position will break the connection between the mains and the distribution board. In this position the mains supply and the generator supply are completely isolated from the distribution board and each other, preventing the possibility of the mains and generator supplies being connected simultaneously.

The third position makes the connection between the generator and the distribution board and should be selected once the generator is running.

Fig 7.9 MTS selector switch

The types of manual transfer switch selector switch :

Fig 7.10 external MTS selector switch

Fig 7.11 MTS selector switch

Automatic Transfer Switch (ATS)

Monitor the power supplies and automatically switch from the normal (utility) supply over to the generator supplied power source in the event of a power outage.
ATS equipment can have many different control and alarm features. An ATS, with built in logic, can monitor the utility power, sense any power disruptions, and switch to an alternate power source.
Some ATS equipment can even start and stop the generator on a predetermined maintenance schedule to assure the back-up generator works when you need it.

Fig 7.12 ATS panel

We can divide the change over control circuit to three types :

1. By using relays ,timers and contactor
2. By using plc
3. By using change over device (AMF)

By using relays ,timers and contactor

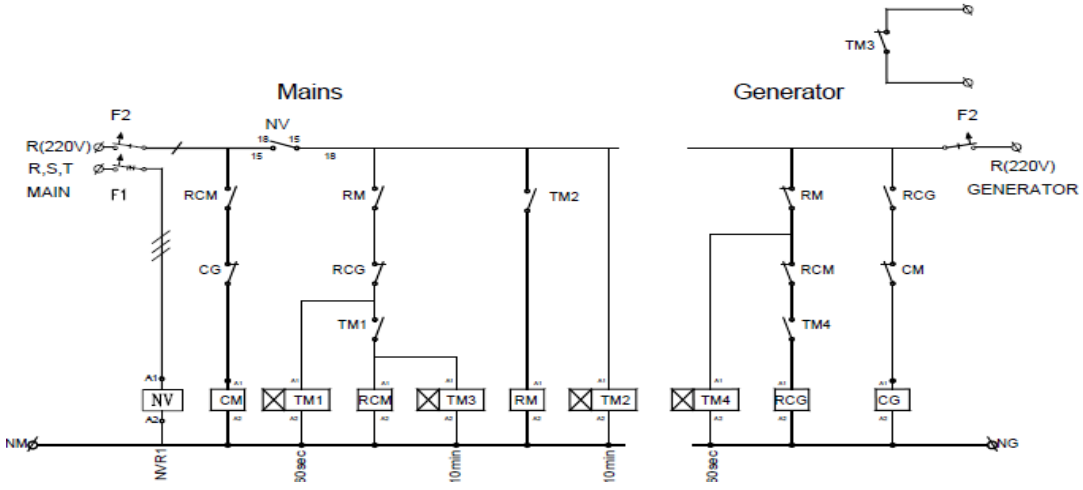

Fig 7.13 ATS control circuit by using relay and timers

The circuit used to control the power transfer from the main circuit to the generator . The default case is that the loads is connected to the main source CM is connected, but if at least one of phases is lost, the control circuit will change the state that is the loads should be transferred to the generator via CG contactor.

By using plc

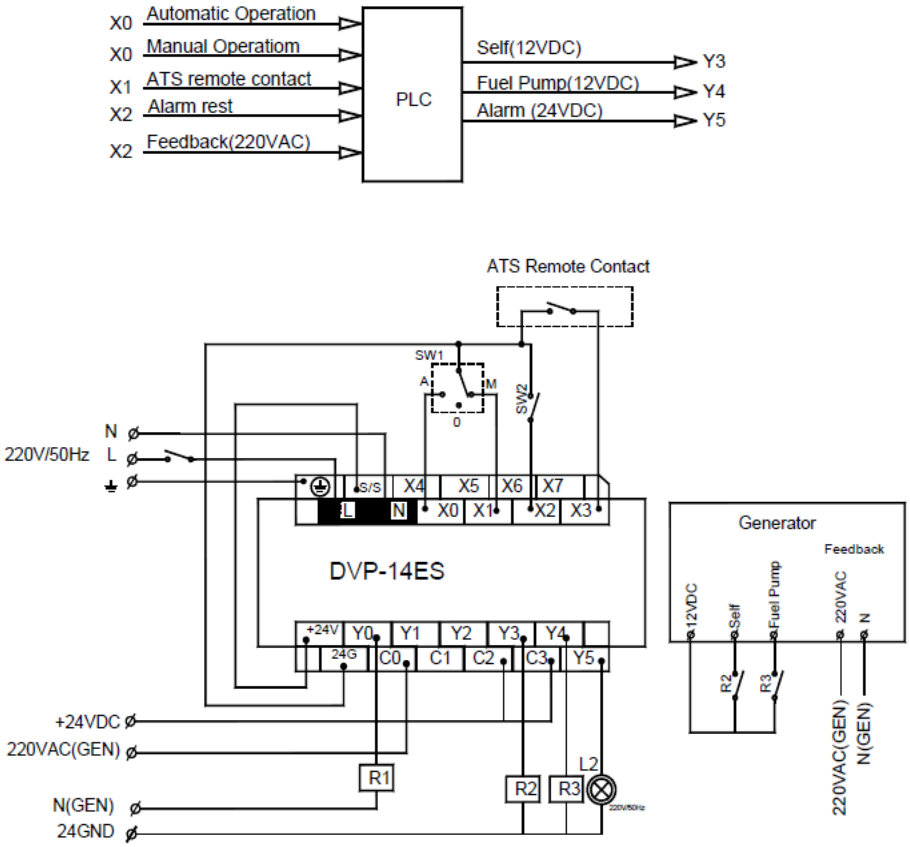

Fig 7.14 Generator self stating control diagram

By using change over device (AMF)

Automatic Mains Failure Unit Operation panel and generator packages are designed to provide emergency power during a mains supply failure. During operation, the control panel of the AMF monitors the mains entering the building.

If a mains failure occurs, the panel will disconnect the mains from the load, the generator is started and its output connected to the load. (The load being appliances, lights, etc in use within the house/office/factory at the time of mains failure). The generator continues to supply the building until the mains supply returns. The generator then automatically disconnects, stops and the mains is re-connected to the load. The AMF panel reverts to the standby mode ready to respond in the event of another mains failure.

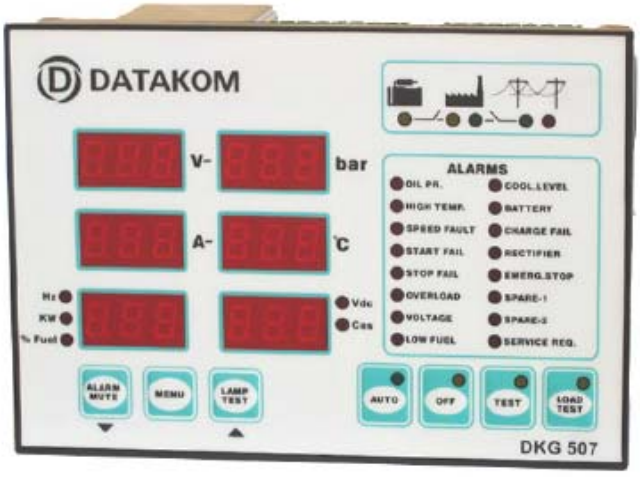

Fig 7.15 AMF device

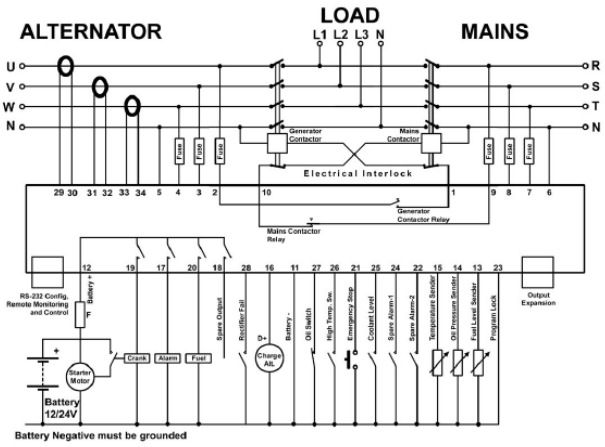

Fig 7.16 control circuit at AMF device

Fig 7.17 The panel used in the laboratory

Generator synchronizing boards

7.3.1 Introduction

It is the intention of this presentation to provide an explanation of the automatic synchronizing process, to explore the considerations involved and to look at some synchronizing applications, as well as to provide a guide for selection of the proper synchronizer for the application.

Definition

Synchronizing, in its simplest form, is the process of electrically connecting additional generators to an existing bus or on-line generator(s).

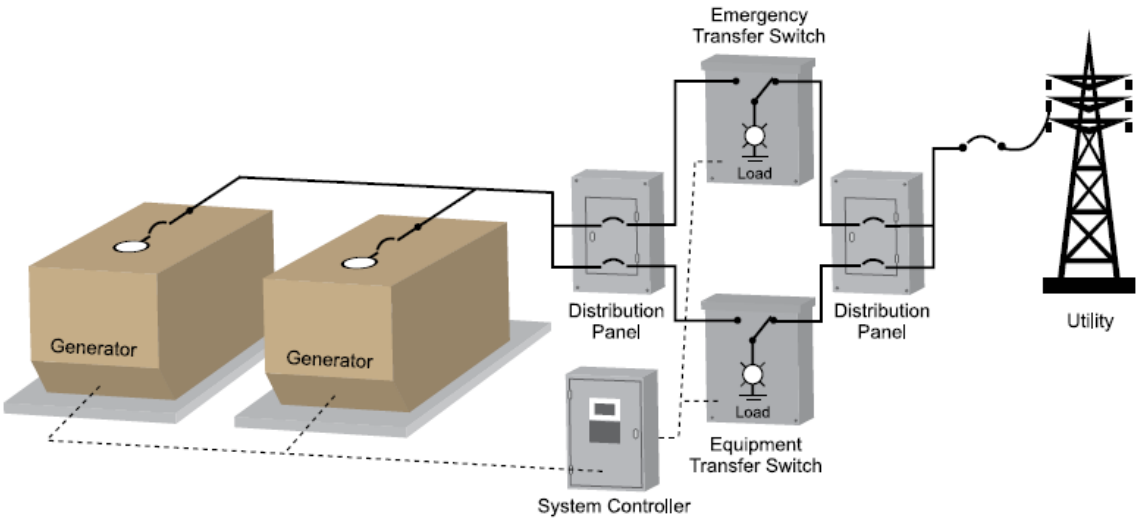

Fig 7.18 parallel generator

7.3.2 Necessity for Synchronizing

The necessity for synchronizing and parallel generator operation is predicated on several factors that must be considered. They are:

- When the rated generating capacity of an existing system has been exceeded by new load demands.
- When enhanced reliability (multiple generating vs. single unit generating) is to be considered.
- When operating efficiency of generator sets is a valid concern (i.e., the ability to add or remove generating sets as necessary) synchronizing will be required.
- When the economics of cogeneration and/or peak load shaving is to be considered.

These additional generators will be connected to operate in parallel to each other and supply power to the same load. The additional oncoming generators must be paralleled properly to ensure:

- The generators supply the proper power to the load.
- Power transients are minimized.
- System stability is maintained.

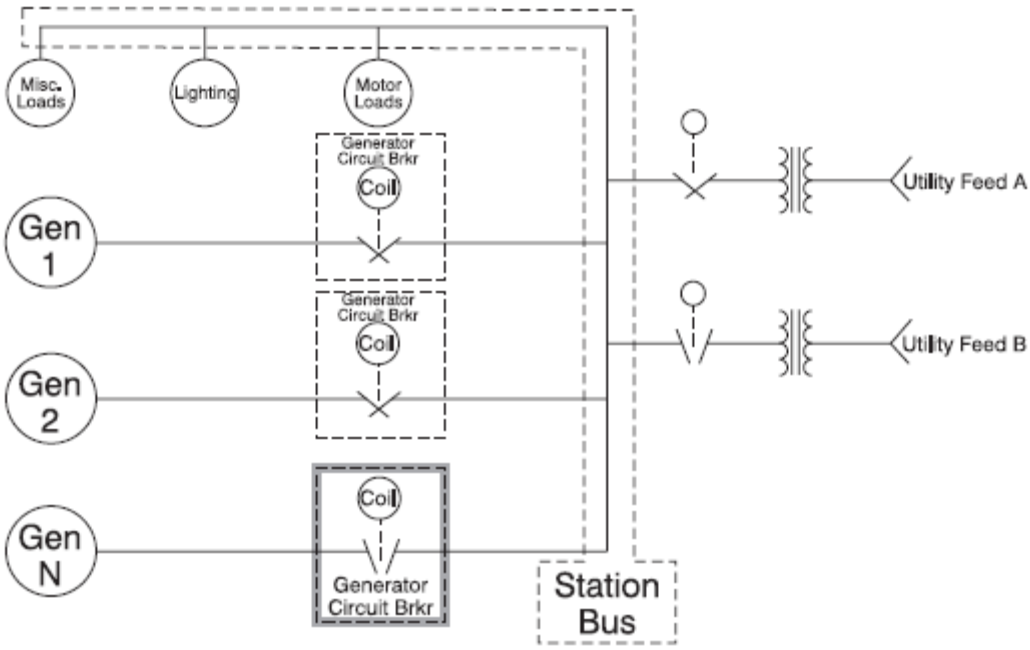

Fig 7.19 Typical industrial facility with its own on-site generators

7.3.3 The Conditions for Synchronization

Pre conditions to be satisfied before two sets can be paralleled (synchronized):-

- Voltage of both the DG sets should be same. Instrument used to ensure this is dual voltmeter.
- Frequency (RPM) – of both the sets should be same. Instrument used is dual frequency meter.
- Phase of both the voltages should be same. Instrument used to ensure this is phase angle meter.

Other methods used to ensure above three conditions are:

- Three lamp method for manual synchronization.
- Check synchronization relay for manual synchronization.
- Auto synchronization relay for automatic synchronization.

Controllers used for paralleling:-

1. COMAP
2. WOODWARD
3. GAC
4. DEEPSEA

Fig 7.20 synchronization panel

7.3.4 Types of synchronizing

We will consider that there are three basic levels of synchronizing sophistication:

1) Manual
2) Manual with permissive relay or supervision of some sort .
3) Fully automatic synchronizing.

Manual Synchronizing

Manual synchronizing is widely used on a variety of machines. The basic manual synchronizing system includes synchronizing lights, a synchroscope, some means to monitor the system parameters, and a breaker control device. With manual synchronizing as described in the analogy above, the operator controls the
speed and voltage of the oncoming generator as well as the closure of the breaker device. The chief advantages of manual synchronizing are system simplicity and low cost.

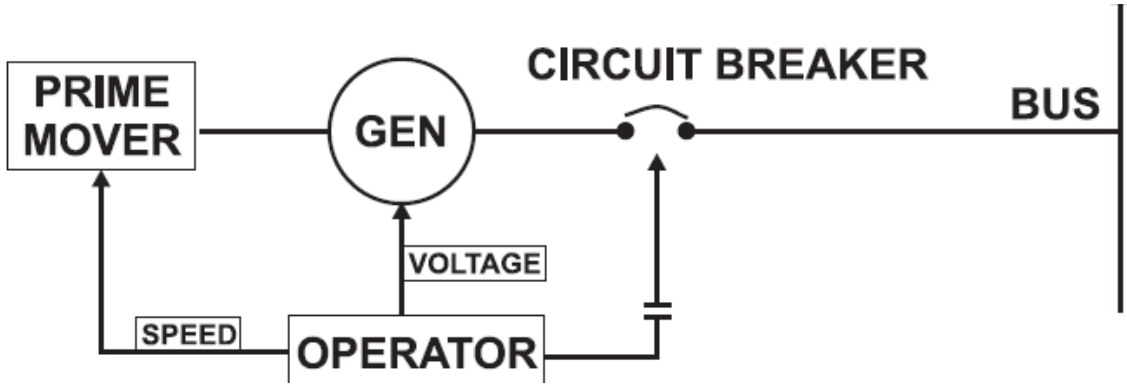

Fig 7.21 Manual Synchronizing

The synchroscope:

a multiple parameter information source. It tells you if there is a slip rate (a frequency difference between generator and bus) and if the generator frequency is running slower or faster than the bus frequency by causing the pointer to rotate in a counterclockwise **.**

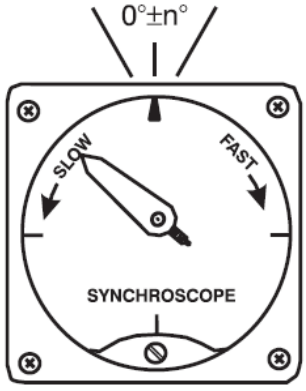

Fig 7.22 synchroscope

Manual With Permissive Relay

This level of synchronizing sophistication is identical to that described previously, with the exception of the addition of a sync-check or sync-verification device, The sync-check device is provided to back up the operator's decision to close the generator, breaker.

In other words, the sync-check device only allows breaker closure to occur when the phase angle, frequency and voltage are within predetermined limits. Although not recommended, operators have been known to hold the breaker control switch closed until the sync-check device permits the circuit breaker close circuit to be energized.

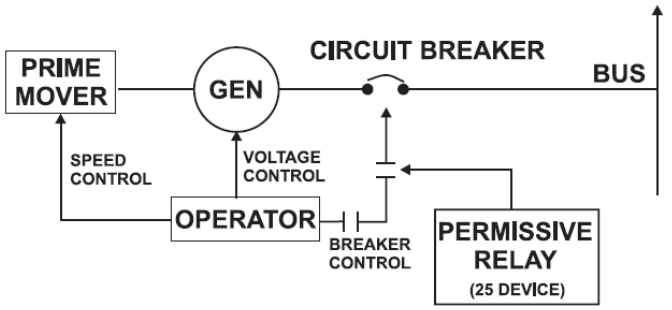

Fig 7.23 Manual With Permissive Relay Synchronizing

Fully Automatic Synchronizing

With fully automatic synchronizing, as its name implies, all functions are provided automatically.

The automatic synchronizer monitors frequency, voltage and phase angle and provides correction signals for voltage matching and frequency matching and also provides the breaker closing output contact.

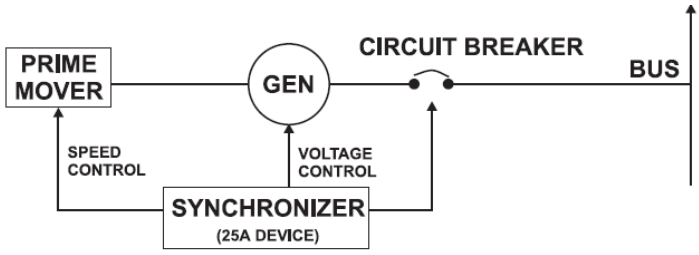

Fig 7.24 Fully Automatic Synchronizing